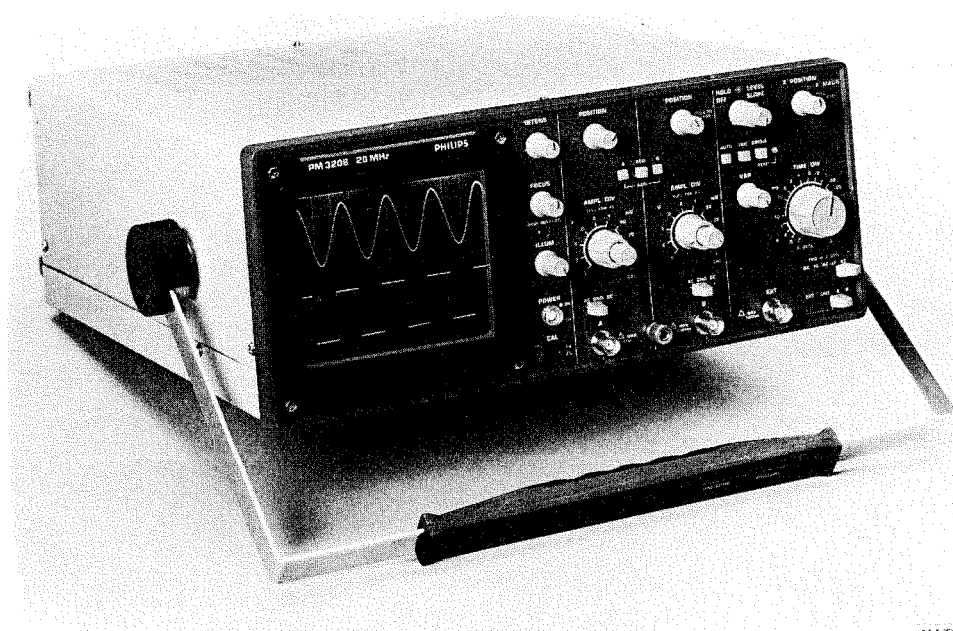


# 20 MHz Dual channel Oscilloscope PM3208

## Service Manual

4822 872 05336

890701



MAT3645



# PHILIPS

## IMPORTANT

In correspondence concerning this instrument please quote the typenumber and serial number as given on the type plate.

**NOTE:**

*The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.*

# Table of Contents

<b>1 SAFETY INSTRUCTION</b>	<b>1 - 1</b>
1.1 INTRODUCTION .....	1 - 1
1.2 SAFETY PRECAUTIONS .....	1 - 1
1.3 CAUTION AND WARNING STATEMENTS .....	1 - 1
1.4 SYMBOLS .....	1 - 1
1.5 IMPAIRED SAFETY-PROTECTION .....	1 - 2
1.6 GENERAL CLAUSES .....	1 - 2
 <b>2 CHARACTERISTICS</b>	 <b>2 - 1</b>
2.1 DISPLAY .....	2 - 2
2.2 VERTICAL DEFLECTION OR Y AXIS .....	2 - 2
2.3 CHANNELS A AND B .....	2 - 2
2.4 EXTERNAL INPUT .....	2 - 4
2.5 HORIZONTAL DEFLECTION OR X AXIS .....	2 - 4
2.6 MAIN TIME BASE .....	2 - 4
2.7 EXTERNAL HORIZONTAL DEFLECTION .....	2 - 5
2.8 TRIGGER MTB .....	2 - 5
2.9 BLANKING OR Z AXIS .....	2 - 6
2.10 CALIBRATOR .....	2 - 6
2.11 POWER SUPPLY .....	2 - 6
2.12 ENVIRONMENTAL .....	2 - 7
2.13 SAFETY .....	2 - 8

### 3 BLOCK DIAGRAM DESCRIPTION 3 - 1

3.1 VERTICAL DEFLECTION .....	3 - 1
3.2 HORIZONTAL DEFLECTION .....	3 - 2
3.3 POWER SUPPLY .....	3 - 2

### 4 CIRCUIT DESCRIPTION 4 - 1

4.1 VERTICAL DEFLECTION .....	4 - 1
4.1.1 Attenuator .....	4 - 1
4.1.2 Preamplifier .....	4 - 1
4.1.3 Intermediate amplifier .....	4 - 1
4.1.4 Y-out amplifier .....	4 - 1
4.1.5 Vertical switching circuit .....	4 - 1
4.1.6 Vertical output amplifier .....	4 - 2
4.2 HORIZONTAL DEFLECTION .....	4 - 2
4.2.1 Trigger amplifier .....	4 - 2
4.2.2 Trigger generator .....	4 - 2
4.2.3 Main time-base (MTB) sweep generator .....	4 - 3
4.2.4 Horizontal switching circuit .....	4 - 3
4.2.5 Horizontal output amplifier .....	4 - 4
4.3 CRT CIRCUIT .....	4 - 5
4.3.1 Z-axis amplifier .....	4 - 5
4.3.2 CRT control .....	4 - 6
4.3.3 HV supply .....	4 - 6
4.4 CALIBRATOR .....	4 - 6
4.5 POWER SUPPLY .....	4 - 7

**5 PERFORMANCE CHECK AND ADJUSTMENT PROCEDURE****5 - 1**

5.1 GENERAL INFORMATION .....	5 - 1
5.2 RECOMMENDED TEST AND CALIBRATION EQUIPMENT .....	5 - 4
5.3 PERFORMANCE CHECK AND ADJUSTMENT PROCEDURE .....	5 - 5
5.3.1 Power supply low voltage .....	5 - 5
5.3.2 Power supply high voltage.....	5 - 5
5.3.3 Power consumption.....	5 - 5
5.3.4 CRT intensity adjustment .....	5 - 5
5.3.5 CRT focus adjustment.....	5 - 5
5.3.6 CRT astigmatism adjustment.....	5 - 6
5.3.7 Vertical step balance adjustment .....	5 - 6
5.3.8 Vertical x5 MAG balance adjustment.....	5 - 6
5.3.9 Vertical variable gain balance adjustment.....	5 - 6
5.3.10 Vertical gain .....	5 - 6
5.3.11 Vertical x5 MAG gain.....	5 - 7
5.3.12 Channel B invert adjustment .....	5 - 7
5.3.13 ADD balance adjustment.....	5 - 8
5.3.14 Low frequency response adjustment.....	5 - 8
5.3.15 High frequency response adjustment.....	5 - 8
5.3.16 1 kHz square-wave response adjustment.....	5 - 8
5.3.17 Input impedance adjustment.....	5 - 9
5.3.18 Dual A and B, polarity inversion channel B.....	5 - 9
5.3.19 ADD facility.....	5 - 9
5.3.20 Vertical bandwidth .....	5 - 10
5.3.21 Trigger DC balance adjustment .....	5 - 10
5.3.22 Y-out DC balance adjustment .....	5 - 10
5.3.23 Y-out gain adjustment.....	5 - 10
5.3.24 X-gain adjustment.....	5 - 11
5.3.25 Triggering adjustment.....	5 - 11
5.3.26 Trace starting point adjustment.....	5 - 11
5.3.27 X-Y centering adjustment .....	5 - 11
5.3.28 Horizontal bandwidth .....	5 - 12
5.3.29 Z input .....	5 - 12

5.3.30	MTB deflection coefficients.....	5 - 12
5.3.31	Sweep length adjustment.....	5 - 13
5.3.32	x10 MAG time adjustment.....	5 - 13
5.3.33	x10 MAG centre balance adjustment.....	5 - 14

## 6 DISMANTLING THE INSTRUMENT 6 - 1

6.1	GENERAL INFORMATION.....	6 - 1
6.2	REMOVING THE TOP- AND BOTTOM COVERS.....	6 - 1
6.2.1	Removing the top cover.....	6 - 1
6.2.2	Removing the bottom cover.....	6 - 1
6.2.3	Remounting the covers.....	6 - 1
6.3	ACCESS TO PARTS FOR CHECKING AND ADJUSTING PROCEDURE.....	6 - 2

## 7 CORRECTIVE MAINTENANCE 7 - 1

7.1	REPLACEMENTS.....	7 - 1
7.1.1	Standard parts.....	7 - 1
7.1.2	Special parts.....	7 - 1
7.1.3	Transistors and integrated circuits.....	7 - 1
7.2	REMOVING AND REMOUNTING THE UNITS.....	7 - 2
7.2.1	Removing the vertical PCB.....	7 - 2
7.2.2	Removing the horizontal PCB.....	7 - 2
7.2.3	Removing the cal and control PCB.....	7 - 3
7.2.4	Removing the mode PCB.....	7 - 4
7.2.5	Removing the CRT.....	7 - 4
7.2.6	Replacing the text plate.....	7 - 5

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**8 SAFETY INSPECTION AND TEST AFTER REPAIR IN THE PRIMARY CIRCUIT 8 - 1**

8.1 GENERAL DIRECTIVES .....	8 - 1
8.2 SAFETY COMPONENTS .....	8 - 1
8.3 CHECKING THE PROTECTIVE EARTH CONNECTION .....	8 - 1
8.4 CHECKING THE INSULATION RESISTANCE .....	8 - 1
8.5 CHECKING THE LEAKAGE CURRENT .....	8 - 1
8.6 VOLTAGE TEST .....	8 - 2

**9 PARTSLIST 9 - 1**

9.1 MECHANICAL PARTS .....	9 - 1
9.2 UNITS .....	9 - 12
9.3 CABLES AND CONNECTORS .....	9 - 12
9.4 ELECTRICAL PARTS.....	9 - 13
9.4.1 Special capacitors .....	9 - 13
9.4.2 Trimmer capacitors.....	9 - 14
9.4.3 Special resistors.....	9 - 14
9.4.4 Trimmer resistors .....	9 - 14
9.4.5 Potentiometers .....	9 - 15
9.4.6 Diodes .....	9 - 15
9.4.7 Transistors.....	9 - 17
9.4.8 Integrated circuits.....	9 - 19
9.4.9 Miscellaneous .....	9 - 20

**10 CIRCUIT DIAGRAMS + PCB LAY OUTS 10 - 1**

# List of Figures

Figure 2.1 Maximum input voltage versus frequency .....	2 - 3
Figure 3.1 Block diagram.....	3 - 3
Figure 5.1 Adjusting elements on vertical pcb .....	5 - 3
Figure 5.2 Adjusting elements on horizontal pcb .....	5 - 3
Figure 6.1 Dismantling the instrument .....	6 - 2
Figure 7.1 Removing vertical pcb.....	7 - 2
Figure 7.2 Removing horizontal pcb.....	7 - 3
Figure 7.3 Removing Cal and control pcb.....	7 - 3
Figure 7.4 Removing mode pcb.....	7 - 4
Figure 7.5 Removing text plate.....	7 - 5
Figure 9.1 Housing .....	9 - 3
Figure 9.2 Front panel .....	9 - 5
Figure 9.3 Main frame.....	9 - 9
Figure 10.1 Vertical pcb lay out.....	10 - 3
Figure 10.2 Circuit diagram of vertical input .....	10 - 5
Figure 10.3 Vertical pcb lay out.....	10 - 7
Figure 10.4 Circuit diagram of vertical amplifier.....	10 - 9
Figure 10.5 Vertical pcb lay out.....	10 - 11
Figure 10.6 Circuit diagram of vertical output amplifier.....	10 - 13
Figure 10.7 Horizontal pcb lay out.....	10 - 15
Figure 10.8 Circuit diagram of trigger generator .....	10 - 17
Figure 10.9 Horizontal pcb lay out.....	10 - 19
Figure 10.10 Circuit diagram of main time-base generator .....	10 - 21
Figure 10.11 Horizontal pcb lay out .....	10 - 23
Figure 10.12 Circuit diagram of horizontal output amplifier.....	10 - 25
Figure 10.13 Vertical pcb lay out showing parts of power supply .....	10 - 27
Figure 10.14 Cal and control pcb lay out .....	10 - 28
Figure 10.15 Circuit diagram of power supply + miscellaneous .....	10 - 29
Figure 10.16 Horizontal pcb lay out .....	10 - 31
Figure 10.17 CRT pcb lay out.....	10 - 32
Figure 10.18 Circuit diagram of Z - amplifier + CRT .....	10 - 33
Figure 10.19 Mode pcb lay out .....	10 - 35
Figure 10.20 Cal and control pcb lay out .....	10 - 35



# 1 SAFETY INSTRUCTION

Read these pages carefully before installation and use of the instrument.

## 1.1 INTRODUCTION

The following clauses contain information, cautions and warnings which must be followed to ensure safe operation and to retain the instrument in a safe condition. Adjustment, maintenance and repair of the instrument shall be carried out only by qualified personnel.

## 1.2 SAFETY PRECAUTIONS

For the correct and safe use of this instrument it is essential that both operating and servicing personnel follow generally-accepted safety procedures in addition to the safety precautions specified in this manual. Specific warning and caution statements, where they apply, will be found throughout the manual. Where necessary, the warning and caution statements and/or symbols are marked on the apparatus.

## 1.3 CAUTION AND WARNING STATEMENTS

**CAUTION:** Is used to indicate correct operating or maintenance procedures in order to prevent damage to or destruction of the equipment or other property.

**WARNING:** Calls attention to a potential danger that requires correct procedures or practices in order to prevent personal injury.

## 1.4 SYMBOLS



High voltage 1000 V (red)



Live part (black/yellow)



Read the operating instructions



Protective earth (grounding) terminal (black)

## 1.5 IMPAIRED SAFETY-PROTECTION

Whenever it is likely that safety-protection has been impaired, the instrument **must** be made inoperative and be secured against any unintended operation. The matter should then be referred to qualified technicians. Safety-protection is likely to be impaired if, for example, the instrument fails to perform the intended measurements or shows visible damage.

## 1.6 GENERAL CLAUSES

**WARNING:** The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts and accessible terminals which can be dangerous by live.

- The instrument shall be disconnected from all voltage sources before it is opened.
- Bear in mind that capacitors inside the instrument can hold their charge even if the instrument has been separated from all voltage sources.

**WARNING:** Any interruption of the protective earth conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

- Components which are important for the safety of the instrument may only be renewed by components obtained through your local Philips organisation. (See also section 8).
- After repair and maintenance in the primary circuit, safety inspection and tests, as mentioned in section 8 have to be performed.

## 2 CHARACTERISTICS

### Performance Characteristics

Properties expressed in numerical values with stated tolerance are guaranteed by PHILIPS. Specified non-tolerance numerical values indicate those that could be nominally expected from the mean of a range of identical instruments.

This specification is valid after the instrument has warmed up for 30 minutes (reference temperature 23 °C).

For definitions of terms, reference is made to IEC Publication 351-1.

### Safety Characteristics

This apparatus has been designed and tested in accordance with Safety Class I requirements of IEC Publication 348, Safety requirements for Electronic Measuring Apparatus and has been supplied in a safe condition.

### Initial Characteristics

Overall dimensions:

Width : 356 mm

Length : 435 mm

Height : 147 mm

Mass : 9 kg

Operating positions:

- a. Horizontally on bottom feet
- b. Vertically on rear feet
- c. On the carrying handle in two sloping positions.

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
<b>2.1 DISPLAY</b>		
Cathode ray tube	150 DEB31	150 mm rectangular single beam domed mesh tube.
Measuring area (h x w)	80 mm x 100 mm	8 div x 10 div
Screen type	GH (P31)	
Total acceleration voltage	2 kV	
Graticule	internal, fixed	
Illumination	continuously variable	

## 2.2 VERTICAL DEFLECTION OR Y AXIS

Deflection sources	Channel A Channel B	Channel B can be inverted (allowing for A-B in ADDED position)
	Ch. A and Ch. B ADDED	
Deflection modes	1 Channel only Channel A&B ADDED or subtracted 2 Channels chopped 2 Channels alternated	A $\pm$ B MTB: 0,5 s/div...1 ms/div and in X-Y operation MTB: 0,5 ms/div...0,2 $\mu$ s/div
Chop frequency	250 kHz $\pm$ 20 %	
Y signal output: source	Channel A	
output voltage into 1 M $\Omega$	100 mV/div	
output voltage into 50 $\Omega$	50 mV/div	

## 2.3 CHANNELS A AND B

Input connector	BNC	
Input impedance:		Measured at frequencies < 1 MHz
R parallel	1 M $\Omega$ $\pm$ 2 %	In AC pos. of input coupling: 22 nF in series with R par. and C par. In GND pos.: R par = $\infty$
C parallel	30 pF	
max. input cap. difference	2 pF	
Input coupling	d.c., a.c., ground	In GND position: channel disconnected from input BNC and connected to ground

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
Input voltage limits (d.c. + a.c. peak)	$\pm 400\text{ V}$	Instrument should be properly grounded through the protective-ground conductor of the power cord. Up to 1 MHz; for > 1 MHz see figure below

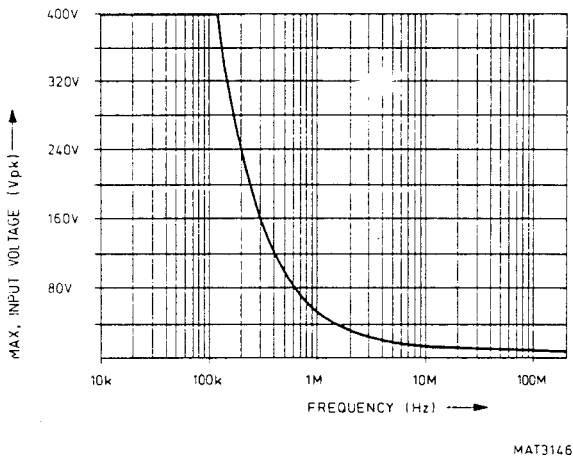


Figure 2.1 Maximum input voltage versus frequency.

Deflection coefficient:		
steps	5 mV/div...5 V/div 1 mV/div...1 V/div	In a 1-2-5 sequence of 10 steps x5 magnification Add 2 % in x5 magnification When channel is used for X Deflection, see Section 2.8
error limit	$\pm 5\%$	Uncalibrated, continuously variable between steps
VARIABLE gain range	2,5 : 1 (minimum)	
Frequency response:		When used for Y Deflection (for X Deflection, see Section 2.8). Source impedance: 25 $\Omega$
lower transition point of BW:		
input coupling in DC position.	d.c.	
input coupling in AC position.	< 10 Hz	
upper transition point of BW:		
x1	> 20 MHz	
x5	> 10 MHz	
Pulse response:		
rise time x1	$\leq 17,5\text{ ns}$	Calculated from BW x Rise time = 0,35
rise time x5	$\leq 35\text{ ns}$	Calculated from BW x Rise time = 0,35

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
<b>2.4 EXTERNAL INPUT</b>		
Input connector	BNC	
Input impedance: R parallel	$1\text{ M}\Omega \pm 2\%$	Measured at frequencies < 1 MHz.
C parallel	30 pF	
Input voltage limits (d.c. + a.c. peak)	$\pm 100\text{ V}$	Instrument should be properly grounded through the protective-ground conductor of the power cord

## 2.5 HORIZONTAL DEFLECTION OR X AXIS

Deflection sources	MTB EXT. through Ch. A Through EXTERNAL input  Line	See Section 2.7 Selected by MTB trigger source selector
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## 2.6 MAIN TIME BASE

Modes	repetitive single	
Deflection coefficient: TB magnifier: OFF steps error limit TB magnifier: x10 steps error limit VARIABLE gain range	$0,2\text{ }\mu\text{s/div} \dots 0,5\text{ s/div}$ $\pm 3\%$  $20\text{ ns/div} \dots 50\text{ ms/div}$ $\pm 5\%$ $2,5 : 1\text{ (minimum)}$	In a 1-2-5 sequence of 20 steps Measured over central 8 div  In a 1-2-5 sequence of 20 steps Measured over central 8 div Uncalibrated, continuously variable between steps
Hold-off: variable between	1...2x minimum hold-off	

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
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## 2.7 EXTERNAL HORIZONTAL DEFLECTION

Deflection sources	Channel A EXTernal input	Selected by MTB trigger source selector
Channel deflection: deflection coefficient error limit	see channels A and B $\pm 10 \%$	Except error limit Measured over central 8 div
Frequency response: lower transition point of BW	see appropriate channel	Input coupling of channel and coupling of MTB trigger are cascaded
upper transition point of BW	$\geq 1 \text{ MHz } (-3 \text{ dB})$	
Deflection via EXTernal input: deflection coefficient error limit	0,1 V/div $\pm 15 \%$	
Frequency response: lower transition point of BW	d.c. $\leq 10 \text{ Hz } (-3 \text{ dB})$	Coupling switch in DC position Coupling switch in AC or AC-LF position
upper transition point of BW	$\geq 1 \text{ MHz } (-3 \text{ dB})$ 15 kHz	Coupling switch in DC position Coupling switch in AC-LF position
Max. phase diff. between HOR. and VERT.	$3^\circ$	Up to 50 kHz

## 2.8 TRIGGER MTB

Trigger sources	Channel A Channel B External Line	Line trigger derived from mains
Trigger modes: triggered	TRIG	Time-base starts when trigger occurs
auto	AUTO	Same as TRIG, but bright baseline is displayed if during 0,1 s no trigger has occurred
single sweep	SINGLE	Same as TRIG, but only for first time after SINGLE has been activated and after RESET
Coupling of channel	DC AC AC-LF  TV	Approx. 10 Hz $(-3 \text{ dB})$ Bandpass: approx. 10 Hz...15 kHz $(-3 \text{ dB})$ TVF: 0,5 s/div...0,1 ms/div TVL: 50 $\mu\text{s/div}$ ...0,2 $\mu\text{s/div}$

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
Min. trigger sensitivity:		
d.c. to 1 MHz	1 div	Trigger level not in fixed position
via EXT input	150 mV	Trigger level not in fixed position
d.c. to 40 MHz	2 div	Trigger level not in fixed position
via EXT input	300 mV	Trigger level not in fixed position
TV (ampl. of sync. pulse)	1 div	Positive and negative video, selection via SLOPE switch
via EXT input	100 mV	Positive and negative video, selection via SLOPE switch
SLOPE selection:	positive going (+) negative going (-)	
LEVEL control range	$\pm 7$ div	Typical

## 2.9 BLANKING OR Z AXIS

Input coupling	d.c.	
Input voltage limits	$\pm 42$ V	At max. 1 kHz
Sensitivity	3 V (p-p)	Pos. signal blanks display

## 2.10 CALIBRATOR

Wave form-shape	square-wave
Output voltage (p-p)	1 V
Frequency	1 kHz

## 2.11 POWER SUPPLY

Source voltage a.c. (r.m.s.):		
nominal	100, 120, 220, 240 V	Factory installed
limits of operation	Nominal voltage $\pm 10$ %	
Source frequency:		
nominal	50...400 Hz	
limits of operation	48...440 Hz	
Power consumption:		At nominal source voltage
typical	35 W	
maximum	40 W	



## CHARACTERISTICS

## SPECIFICATION

## ADDITIONAL INFORMATION

**2.12 ENVIRONMENTAL**

The environmental data mentioned in this manual are based on the results of the manufacturer's checking procedures. Details on these procedures and failure criteria are supplied on request by the PHILIPS/FLUKE organisation in your country, or by PHILIPS, INDUSTRIAL AND ELECTRO ACOUSTIC SYSTEMS DIVISION, EINDHOVEN, THE NETHERLANDS.

Meets environmental requirements of	MIL-T-28800D Type III Class 5, Style E	
Temperature:		
operating		
min. low temp.	5 °C	MIL-T-28800D par. 3.7.2.3 tested cf. par. 4.5.5.1.1
max. high temp.	+35 °C	MIL-T-28800D par. 3.7.2.4 tested cf. par. 4.5.5.1.1
non operating (storage)		
min. low temp.	-20 °C	MIL-T-28800D par. 3.7.2.3 tested cf. par. 4.5.5.1.1
max. high temp.	+71 °C	MIL-T-28800D par. 3.7.2.4 tested cf. par. 4.5.5.1.1
Maximum humidity:		MIL-T-28800D par. 3.7.2.2 tested cf. par. 4.5.5.1.1
operating and non-operating (storage)	80 % relative humidity	No condensation on instrument when operating
Maximum altitude:		MIL-T-28800D par. 3.7.3 tested cf. par. 4.5.5.2
operating	4,5 km (15 000 feet)	Maximum operating temp. derated 3 °C for each km (for each 3000 feet) above sea level
non-operating (storage)	12 km (40 000 feet)	
Vibration (operating):		MIL-T-28800D par. 3.7.4.1 tested cf. par. 4.5.5.3.1
freq. 5...15 Hz		
sweep time	7 min	
excursion (p-p)	1,5 mm	
max. acceleration	7 m/s <sup>2</sup> (0,7 x g)	At 15 Hz
freq. 15...25 Hz		
sweep time	3 min	
excursion (p-p)	1 mm	
max. acceleration	13 m/s <sup>2</sup> (1,3 x g)	At 25 Hz
freq. 25...55 Hz		
sweep time	5 min	
excursion (p-p)	0,5 mm	
max. acceleration	20 m/s <sup>2</sup> (2 x g)	At 55 Hz
resonance dwell	10 min	At each resonance freq. (or at 33 Hz if no resonance was found). Excursion cf. 21.06.01 to 21.06.03.

CHARACTERISTICS	SPECIFICATION	ADDITIONAL INFORMATION
Shock (operating):		MIL-T-28800D par. 3.7.5.1 tested cf. par. 4.5.5.4.1
amounts of shocks		
total	18	
each axis	6	(3 in each direction)
shock wave-form	half sine wave	
duration	11 ms	
Peak acceleration	300 m/s <sup>2</sup> (30 x g)	
EMC (electro magnetic compatibility):		
meets requirement of	MIL-STD-461 Class B	Applicable requirements of part 7: CE03, CE07, CS01, CS02, CS06, RE02, RS02, RS03. (CS: no malfunction after stimuli)
	VDE 0871 and VDE 0875 Grenzwertklasse B	
Magnetic radiated susceptibility:		Tested cf. IEC 351-1 par. 5.1.3.1
maximum deflection factor	35 mm/mT (3,5 mm/gauss)	Measured with instrument in a homogeneous magnetic field (in any direction with respect to instrument) with a flux intensity (p-p value) of 1,42 mT (14,2 gauss) and of symmetrical sine-wave form with a frequency of 45...66 Hz.

## 2.13 SAFETY

Meets requirements of	IEC 348 Class I
-----------------------	-----------------

## 3 BLOCK DIAGRAM DESCRIPTION

The circuit is located on printed circuit boards and is sub-divided into the following parts:

- vertical deflection
- horizontal deflection
- power supply

The blockdiagram of this instrument is given in figure 3.1. The subdivisions of the diagram do not necessarily relate to the circuit areas of the printed circuit boards.

### 3.1 VERTICAL DEFLECTION

Channel A and Channel B are identical in operation with corresponding circuitry in each channel. Input signals from the BNC input terminals are attenuated through the ATTenuator network circuit. This block has two sections, the first attenuates by ratios of 1:1, 10:1, 100:1 and the second by ratios of 2:1, 5:1, 10:1.

The PRE-AMPLIFIER circuit converts the single-ended input signal from the attenuator into a differential output signal. It includes compensating networks to obtain a good input signal waveform and to adjust square wave response.

Input signals amplified in the PRE-AMPLIFIER are fed to the VERTICAL SWITCHING circuit and to the TRIGGER AMPLIFIER circuit. The TRIGGER AMPLIFIER amplifies the signal for the proper output signals to the TRIGGER SELECTOR and to the HORIZONTAL DEFLECTION unit.

The VERTICAL SWITCHING circuit consists of diode-gate and mode control logic. This stage selects ch. A, ch. B, DUAL or ADD. The MODE CONTROL LOGIC is controlled by the output of this diode-gate and conveys the selected signal to the VERTICAL OUTPUT AMPLIFIER.

The vertical signal derived from the diode switching circuit passes the limiter circuit to obtain an adequate level, and then is fed to the OUTPUT AMPLIFIER. The output obtained is sufficiently amplified by the amplifier with a constant current load. This amplifier is equipped with a booster for high frequency contents to obtain flat signal response. The signal is then fed to the vertical deflection plates of the CRT.

## 3.2 HORIZONTAL DEFLECTION

The TRIGGER GENERATOR receives internal trigger signals from channel A or channel B and an external signal from the EXT BNC bus. This stage amplifies the trigger signal and then activates the SWEEP GENERATOR circuit by clock pulses.

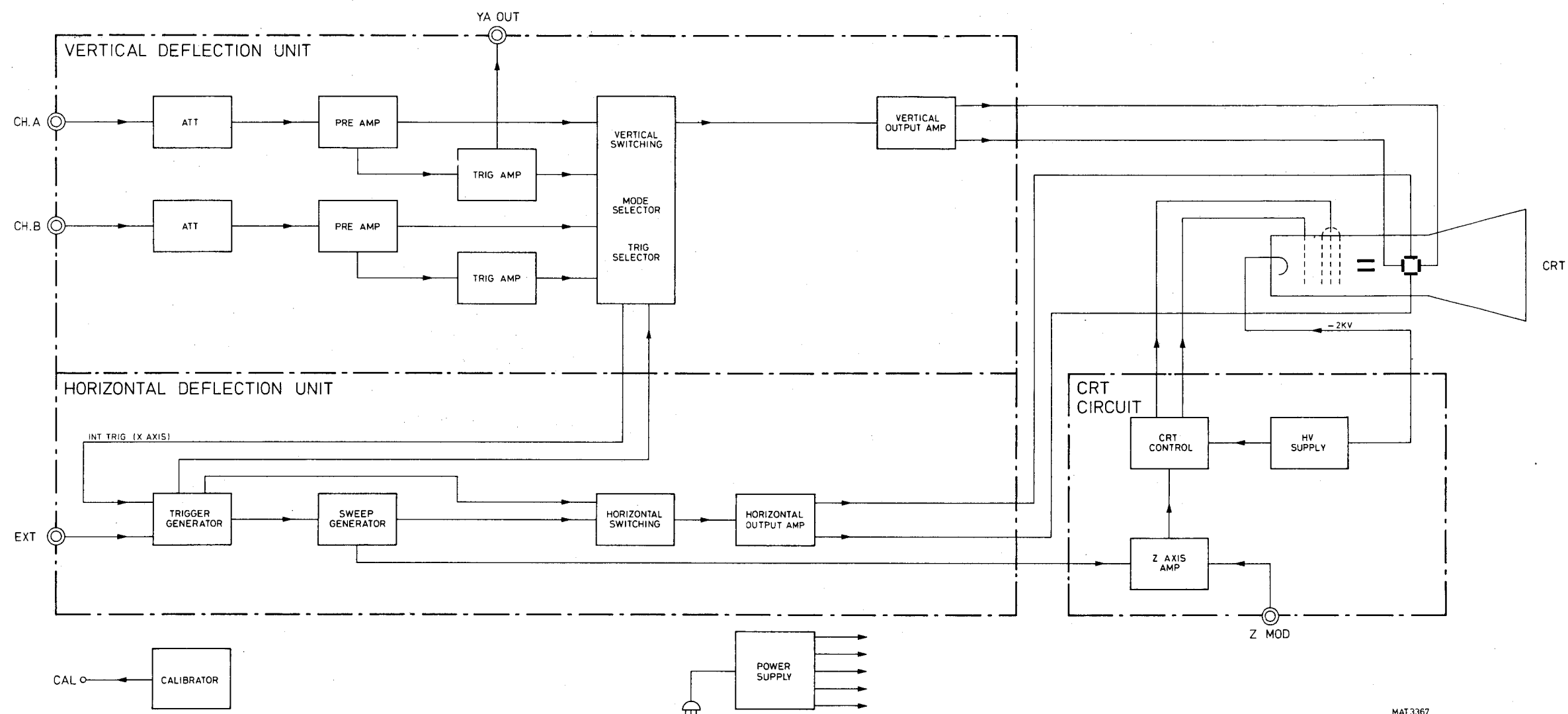
The SWEEP GENERATOR circuit consists of a sweep control circuit, a Miller integrator circuit, a sweep length circuit and a hold off circuit. The sweep is initiated by clock pulses.

The HORIZONTAL SWITCHING circuit is controlled by the TRIGGER SELECTOR and a time selection switch. The trigger selector switch selects the input signal to the TRIGGER GENERATOR. The time selection switch controls the signals from the SWEEP GENERATOR. Output is conveyed to the HORIZONTAL OUTPUT AMPLIFIER.

The HORIZONTAL OUTPUT circuit amplifies the input signals from the SWEEP GENERATOR or TRIGGER SELECTOR by means of a differential amplifier circuit and conveys these to the CRT.

## 3.3 POWER SUPPLY

The POWER SUPPLY circuit is mainly equipped with operational amplifiers. Regulator circuits are used to supply stable voltages. The high voltage for the CRT is supplied by a feed-back DC-DC converter generating the stable – 2 kV high voltage.



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Figure 3.1 Block diagram

## 4 CIRCUIT DESCRIPTION

### 4.1 VERTICAL DEFLECTION

#### 4.1.1 Attenuator

Ch. A and Ch. B are identical. For this reason, only Ch. A will be described. The input signal is fed to the attenuator by means of the input coupling switch S1.

- In position "AC", the input signal is coupled via C2 to block DC components.
- In position "GND", the attenuator input is connected to ground.
- In position "DC", the input is directly connected to the attenuator.

The attenuator consists of two sections. The first one, consisting of S2a and S2b, performs 1:1, 10:1 and 100:1 attenuation. The second one, S2c, performs 2:1, 5:1 and 10:1. Output from the attenuator, a single-ended (asymmetrical) signal, is fed to the preamplifier.

#### 4.1.2 Preamplifier

Ch. A and Ch. B are identical. In the preamplifier, the single-ended output signal from the attenuator is converted into a differential signal by means of IC2. In the preamplifier, compensations and adjustments to obtain a good signal waveform are made.

#### 4.1.3 Intermediate amplifier

Ch. A and Ch. B are practically identical. The only difference is the additional invert facility for Ch. B. The output signals from the vertical preamplifier are fed to the intermediate amplifier where they are amplified in Q5-Q6 and Q7-Q8. (Q105-Q106 and Q107-Q108 in Ch. B). The intermediate amplifier contains the controls for vertical shift, RV54 and RV154, as well as the invert switch for Ch. B. The output signals from the intermediate amplifier are fed to the driver Q201-Q202, under control by the vertical switching circuit.

#### 4.1.4 Y-out amplifier

For external purposes, the vertical signal from Ch. A is also fed to the Y-out amplifier Q11 and from there to a BNC connector at the rear side of the oscilloscope. Input signal for the Y-out amplifier is taken from the first stage in the vertical amplifier Q5-Q6 and fed to Q11 via the trigger amplifier Q9-Q10.

#### 4.1.5 Vertical switching circuit

This circuit consists of the logic circuitry, defining the vertical mode. Part of this circuit is the chopping generator, consisting of IC201. In position "DUAL", Ch. A and Ch. B are displayed alternately at high time-base speeds and chopped at low speeds. The output from the switching circuit defines whether Ch. A or Ch. B is fed to the driver Q201-Q202. Control takes place via the diodes D60...63 and D160...163 by means of the flip-flop IC202 pins 8 and 9.

#### 4.1.6 Vertical output amplifier

The output from the intermediate amplifier is fed to the vertical output amplifier. In this circuit, the vertical signal is amplified to a sufficient amplitude to drive the vertical deflection (Y) plates, of the CRT.

### 4.2 HORIZONTAL DEFLECTION

#### 4.2.1 Trigger amplifier

From the first stage in the vertical amplifier, Q5-Q6, the vertical signal is fed to the trigger amplifier, consisting of Q9-Q10. (Q105-Q106 and Q111-Q112 for Ch. B). The mode-selector in the vertical switching circuit defines whether Ch. A or Ch. B is fed to the trigger generator. Control takes place via the diodes D75-76-175-176 by means of the flip-flop IC202 pins 5 and 6.

#### 4.2.2 Trigger generator

Input signals to the trigger generator are:

- internal trigger signal Ch. A or Ch. B from the trigger amplifier
- line trigger signal from the line-transformer via R1025
- external trigger signal from the external trigger input

Selecting these signals can be performed with the trigger source switch, S401.

Trigger-mode can be selected by means of the coupling switch, S402.

- In position "AC", only a.c. signals perform triggering. (from 10 Hz)
- In position "AC-LF", a.c. signals between 10 and 15000 Hz perform triggering.
- In position "TV", triggering on TV-frame pulses is possible.
- In position "DC", there are no restrictions. This means that all kinds of signal will act as trigger pulses.

The trigger level is adjusted with the level-potmeter RV441a, by means of Q404-Q405.

Triggering on the positive or negative-going edge of the signal is defined by the slope switch, part of RV441, which determines whether the trigger signal is taken from Q404 or Q405. The trigger pulse is amplified and via a gating circuit IC401 fed to the sweep generator. In the trigger generator, also provisions have been made for horizontal (X) deflection. In this case, the horizontal deflection is not controlled by the time-base generator, but by other signals. The kind of horizontal signal can be selected by means of the trigger source switch. In this case, the output from Q403 via CN404 is used to drive the horizontal deflection. Hold-off control potmeter RV441b is part of the sweep generator and will be described in that section.

#### 4.2.3 Main time-base (MTB) sweep generator

The function of the time-base generator is to produce a ramp-voltage, to drive the horizontal amplifier. IC603 together with Q611 act as a current source. The magnitude of the current can be adjusted with S602a, the TIME/DIV switch and with RV614, the variable control MTB VAR. The ramp-voltage is made in the time-base capacitors C606-607 by charging these with the current from the current source. As in the range  $1\mu\text{s} \dots 500\mu\text{s}$  the same currents are used as in the range  $1\text{ms} \dots 500\text{ms}$ , the capacitor is, at the lower speeds, increased by a factor of 1000 by shunting C607 with C608. This is realised with Q607 which acts as a switch, controlled by Q609, D611 and a section of S602. The ramp-voltage is available at Q606-drain and via Q612 sent to the horizontal switching circuit. In position "X DEFL" of the TIME/DIV switch, the current source is switched off. Thus, the time-base capacitor can not be charged and there will be no ramp-voltage.

The time-base is started by a trigger pulse at JK flip-flop IC601 pin 1. At this moment, IC601 pin 6 becomes LOW and Q605 is cut off. From now, the current to the current source Q611 will flow through the time-base capacitors. The ramp-voltage at the time-base capacitor is measured by Q616. When the ramp reaches about +9 V, Q616 turns on and resets one flip-flop of IC601 at pin 14. Due to this, pin 9 will become LOW and also pin 15 does. As a result of this, also the other flip-flop at pin 15 is reset. Terminal 6 will become HIGH and the current from Q603 is transferred from D601 to D602 which will cause Q605 to turn on. This is the end of the sweep and now the time-base capacitors are discharged by Q605. At the end of the discharge-period, Q604 will turn on. After some time, depending on the current through the hold-off transistor Q613, transistor Q615 will turn on and set flip-flop IC601 at pin 10. Now, IC601 pin 15 becomes HIGH, and the time-base circuit can be triggered again. During the hold-off period, a trigger pulse can not start the time-base, as IC601 pin 15 is still LOW. The current through Q613 is controlled by the potmeter RV441b, situated in the trigger generator.

- In position "TRIG" of the sweep-mode switch, the time-base will only start if there are trigger pulses.
- In position "AUTO", the time-base is restarted immediately after flip-flop IC601 at pin 10 has been set. At this moment, from pin 9, IC601 pin 15 will become HIGH and pin 4 LOW. As a consequence, the flip-flop at pin 4 will be set and the time-base starts again. If in position "AUTO" trigger pulses occur, they will overrule the function of the auto circuit. In that case, the trigger pulses turn-on the thyristor circuit Q601-Q602, and IC401 pin 10 is kept LOW. Now, the flip-flop can only be set by trigger pulses at pin 1.
- In position "SINGLE", the input of Q615 is kept LOW via D633. Now, setting flip-flop IC601 at pin 10 by Q615 is not possible. Setting is now performed by pressing the button "SINGLE". This causes IC601 pin 13 to be LOW for some time via C640 and this will set this flip-flop. Now pin 15 becomes HIGH, and the time-base is ready to be triggered for only one sweep. For a new sweep, pushing again the button "SINGLE" is necessary. The lamp "RESET" is lit when the time-base is ready for triggering.

#### 4.2.4 Horizontal switching circuit

The horizontal switching circuit defines whether the MTB or the external horizontal input signal is fed to the horizontal output amplifier. The circuit consists of IC602. Input signals are the MTB at pin 13 and the external horizontal input signal, if any, at pin 15. A control signal is connected to pin 9. This pin is LOW if external X-input has been selected. (position "X DEFL" of the TIME/DIV switch). The output signal of the horizontal switching circuit is available at IC602 pin 4 and from there sent to the horizontal output amplifier.



#### 4.2.5 Horizontal output amplifier

In the horizontal output amplifier, the signal from the horizontal switching circuit is amplified to a sufficient amplitude to drive the horizontal deflection (X) plates of the CRT. The input signal is connected to the base of Q801. In this amplifier, provisions are made for horizontal shift and x10 magnification. Horizontal shift is provided by means of potmeter RV801. Magnification x10 by switch S801, part of RV801.

## 4.3 CRT CIRCUIT

### 4.3.1 Z-axis amplifier

The Z amplifier provides intensity control of the CRT by driving the Wehnelt-cylinder g1 (pin 3), and focus control by means of the focus electrode g3 (pin 4). The voltage to the Wehnelt can be influenced by several signals. Inputs to the Z-axis amplifier are :

- A DC control signal to R3026.  
This voltage is 0 V in position "X DEFL" of the TIME/DIV switch and +5 V in the other positions.
- "INTENS", intensity control to R3029.  
This is a DC signal, 0 to +12 V, from the "INTENSITY" control RV3033. The signal is intended to control the intensity of the beam.
- "MTB UNBLANK", unblanking signal MTB, to D3027.  
During the MTB, this logic signal is HIGH, and the MTB can be displayed.
- "CHOP BLANK", blanking signal to D3029 and D3031.  
This logic signal is HIGH when the trace must be displayed, and LOW during switching from channel A to channel B.
- "Z-AXIS INPUT", to R3001.  
This input consists of external signals, if any, to the BNC connector at the rear-side of the instrument. A positive signal blanks the display; a signal of about 3 V is sufficient to blank a display of normal intensity. All signals mentioned above influence the voltage at g1 and thus the trace intensity.

The signals are input to the amplifier consisting of Q3001...3006. Q3006 is the output transistor intended to drive g1. The DC-level of Q3006-E is about +50 V. At Q3006-E the Z-pulse is available. This is a positive pulse with an amplitude between 0 and 80 V, depending on the intensity control. In position "X DEFL", the Z-pulse is a DC signal, maximum amplitude 80 V, superimposed on the DC level of 50 V. The Z-pulse is fed to g1 via a modulator circuit. This circuit is necessary as the Z-pulse which can be DC, has to be transferred to the DC level of g1, about -2000 V. The modulator is a peak-peak detector, consisting of D3024-3025 and C3014-3018. The input voltage is an AC voltage which is clamped between about +130 V by means of R3019-3020 and D3019, and the output voltage from the Z-amplifier, via D3018 and R3014. This Z-output can be +50 to +130 V, depending on the intensity controls. So the input voltage to the peak-peak detector is an AC voltage with a positive peak of +130 V and a negative peak between +50 and +130 V. Thus, the output from the detector will be 0 to 80 V, depending on the intensity. This voltage is superimposed on the -2000 V and thus, the voltage at g1 can be -2000 V to -1920 V. For good pulse behaviour, the Z-pulse is also transferred via an AC path, C3023.

#### Focus control.

For optimum focussing, the voltage at the focus electrode g3 (pin 4) must depend on the intensity. This means that if the voltage at g1 is increased, the voltage at g3 must be decreased. This is called "dynamic focussing" and it is done by driving g3 with a pulse which has the opposite polarity of the Z-pulse. The opposite Z-pulse is available at Q3005-E and is fed via a similar modulator circuit to g3. Focus adjustment is obtained by the voltage of potmeter VR2011. Focus control takes place by means of the "FOCUS" potmeter RV3035, via R3016

### 4.3.2 CRT control

The CRT has several electrodes.

- The filament, pins 1 and 14, is supplied with 6,3 V (AC) from the line-transformer.
- The cathode, pin 2, is at a fixed potential of  $-2000$  V.
- G1, pin 3, has already been described. The potential is about  $-2000$  V. Intensity control is made by RV3033, "INTENSITY".
- G2, an anode, pin 12, is at a fixed potential of about  $+100$  V, by means of the voltage-divider R2016-2017.
- G3, pin 4, has already been described. The potential is about  $-700$  V. Focus control is made by RV3035, "FOCUS".
- G4 and G5, pin 6, are used for astigmatism control, by means of VR2018. The potential can be adjusted between  $0$  and  $+160$  V.
- The vertical deflection plates, pins 7 and 9, are driven by the vertical output amplifier, as already described.
- The horizontal deflection plates, pins 11 and 13, are driven by the horizontal output amplifier, as already described.
- The trace rotation coil L2001, resistance about  $500\ \Omega$ , has been placed around the CRT and is intended to align the trace with the horizontal graticule-lines. The current through the coil can be adjusted between  $-8$  and  $+12$  mA by means of RV3036, "TRACE ROTATION".
- The illumination of the graticule can be controlled by RV3037, "SCALE ILLUM".

### 4.3.3 HV supply

The  $-2000$  V high-voltage for the CRT is made by means of a DC-DC converter consisting of Q2001, IC2001 and the transformer T2001. The converter is supplied with about  $+18$  V. Voltage control is obtained by means of IC2001. The output of the converter is a sinusoidal AC voltage, available at the secondary winding of T2001. The peak-value of this voltage is about  $1000$  V. The voltage is rectified and multiplied by voltage-doubler C2013-D2011-D2010-C2011 and smoothed with C2013.

## 4.4 CALIBRATOR

In the calibrator circuit, a square-wave voltage for checking purposes is produced. Frequency of the square-wave is about  $1$  kHz. The pulse duty-cycle is  $50\%$  and the peak to peak amplitude  $1$  V. The square-wave is generated in a free-running multivibrator, consisting of two gates of IC4001, pins 4 and 3. The other two gates, pins 11 and 10, are for pulse-shaping. Via the voltage divider R4010-4011-4012 the signal is fed to the probe adjustment output terminal at the front of the instrument.

## 4.5 POWER SUPPLY

Input to the power supply is the mains-voltage; outputs are 6,3 V (AC) to the CRT and 4 DC voltages: - 12 V, + 5 V, + 12 V and + 160 V. The power supply consists of a line-transformer, rectifiers and stabilising circuits.

The function of the line-transformer is:

- Providing a galvanic isolation between the mains-voltage and the electronic circuitry in the oscilloscope.
- Adaptation to the right mains-voltage by means of different primary windings.
- Transforming the mains-voltage into the low voltages needed by the instrument.

The rectifiers convert the AC voltages from the line-transformer into DC voltages. The output from D1002 at C1012 is about 190 V. The output from D1001 is about +18 V at C1001 and - 18 V at C1010.

Stabilisation is obtained by series-pass transistors Q1001-1002-1003-1004 which are controlled by the operational amplifiers IC1001 and 1002. The reference voltage to the +12 V is about +6,2 V from diodes D1004 and D1005. Adjustment of the +12 V is done by means of potmeter VR1006. As reference voltage to the - 12 V, + 5 V and + 160 V stabilisers, the +12 V is used. So, VR1006 will control all voltages and only one adjusting element is needed.

## 5 PERFORMANCE CHECK AND ADJUSTMENT PROCEDURE

### 5.1 GENERAL INFORMATION

The following information provides the complete performance check and adjusting procedure for the instrument. The performance check procedure provides an indication whether an adjustment has to be performed or not.

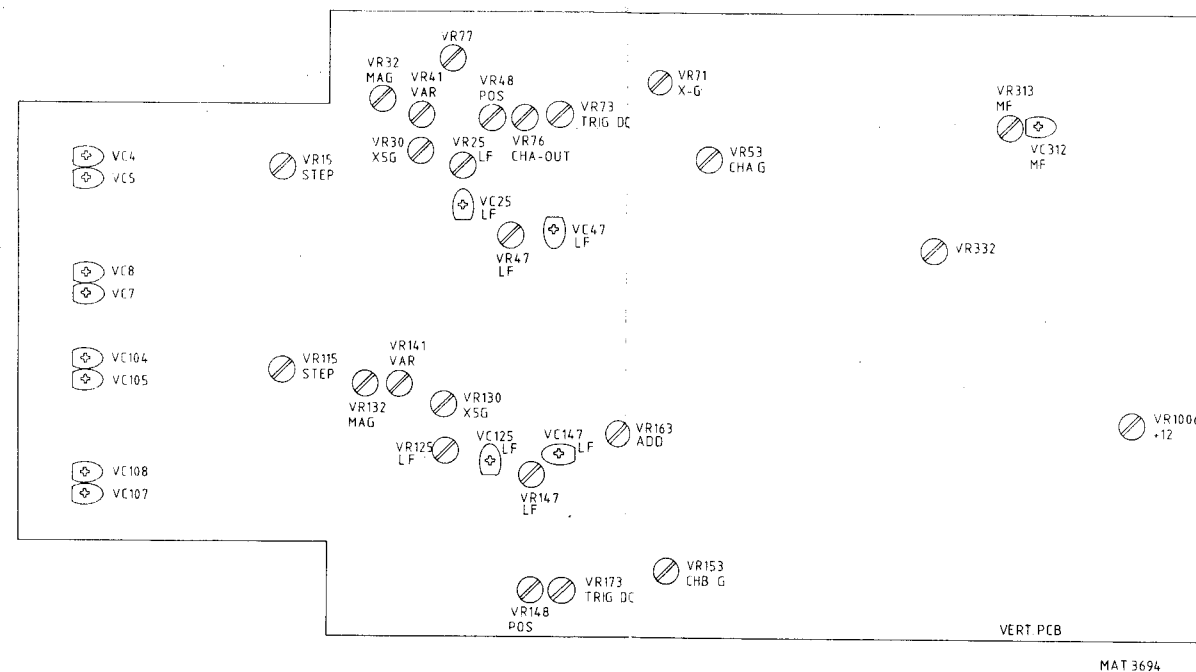
If no adjustment is needed, this is indicated by NO.

As various control functions are interdependent, a certain order of adjustment is necessary. The performance check and adjustment procedure is, therefore, presented in a sequence which is best suited to this order, cross-reference being made to any circuit which may affect a particular adjustment.

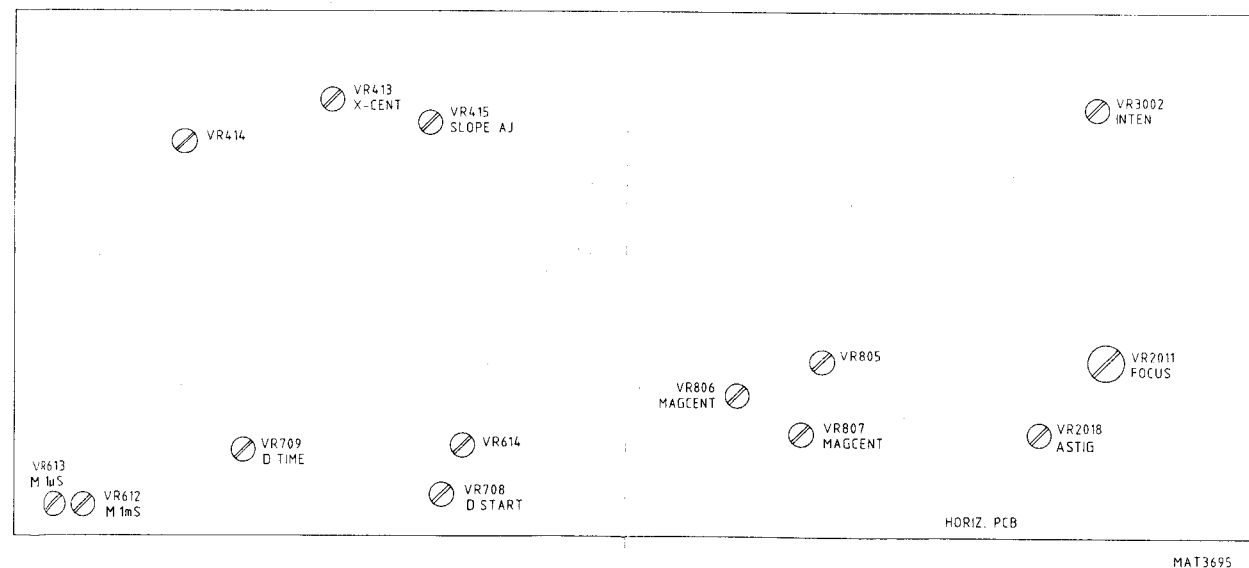
Before any adjustment, the instrument must attain its normal operating temperature.

- Warming-up time under average conditions is 30 minutes.
- All limits and tolerances given in this section are calibration guides and should not be interpreted as instrument specifications, unless they are also published in section 2 "CHARACTERISTICS" of this service manual.
- Tolerances given are for the instrument under test and do not include test equipment error.
- The most accurate display adjustments are made with a stable, well-focussed low intensity display.
- All controls which are mentioned without item numbers are located on the outside of the instrument.

**WARNING:** The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts or live terminals. The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened. If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved. Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.



**Figure 5.1 Adjusting elements on vertical pcb**



**Figure 5.2 Adjusting elements on horizontal pcb**

## 5.2 RECOMMENDED TEST AND CALIBRATION EQUIPMENT

A complete list of all material necessary for both this performance check and adjustment procedure is given below.

Type of instrument	Required specification	Example of recommended instrument
Function generator	Freq: 1...10 MHz Sine-wave/square-wave Ampl: 0...20 V (p-p) DC offset 0...± 5 V Rise-time < 30 ns Duty-cycle 50 %	Philips PM 5134
Constant amplitude sine-wave generator	Freq: 100 kHz...50 MHz Constant peak-peak ampl. of 120 mV and 3 V	Tektronix SG 503
Square-wave calibration generator	For ampl. calibration: Freq: 1 kHz Ampl: 10 mV...50 V For rise-time measurements: Freq: 1 MHz Ampl: 10...500 mV Rise-time: ≤ 1 ns	Tektronix PG 506
Time-marker generator	Repetition rate: 50 ns...0,5 s	Tektronix TG 501
Digital multimeter	Wide voltage, current and resistance ranges. Required accuracy 0,1 %	Philips PM 2524 and high voltage probe PM 9246
Oscilloscope	The bandwidth must be the same or higher than the bandwidth of the instrument under test.	Philips PM 3055
Variable mains transformer	Well-insulated output voltage 90...264 V (ac)	Philips ord.number 2422 529 00005
Watt meter	True RMS meter, e.g. moving iron type.	
Dummy probe 2:1	1 MΩ ± 0,1 % // 20 pF	
Cables, T-piece, terminations for the generators	General Radio types for fast rise-time square-wave and high freq. sine-wave. BNC types for other applications.	
Trimming tool		Philips 800NTX kit (ord.number 4822 310 50015)

## 5.3 PERFORMANCE CHECK AND ADJUSTMENT PROCEDURE

The adjusting elements and measuring pins are given in figures 5.1 and 5.2.  
From every adjusting element the item number and the unit where it is located are given,  
e.g. VR1006 (VERT PCB).

**NOTE:** Always use an insulated adjustment tool!

### 5.3.1 Power supply low voltage

TEST EQUIPMENT	d.c. voltmeter
SETTING	Measure the d.c. voltages at CN1005 (VERT PCB), with respect to ground.
REQUIREMENTS	Check the +12 V at pin 2 (11,88...12,12 V). Check the -12 V at pin 3 (11,88...12,12 V). Check the +5 V at pin 4 (5,00...5,15 V). Check the +160 V at pin 6 (152...168 V).
ADJUSTMENT	Adjust VR1006 (" +12 V ADJ" - VERT PCB) for 11,88...12,12 V.

### 5.3.2 Power supply high voltage

TEST EQUIPMENT	d.c. voltmeter High voltage probe
SETTING	Measure the high voltage at CN2005 pin 3 (HOR PCB), with respect to ground.
REQUIREMENTS	Check that the voltage is -1950...-2050 V.
ADJUSTMENT	NO

### 5.3.3 Power consumption

TEST EQUIPMENT	Watt meter
SETTING	Power on
REQUIREMENTS	Check for a maximum input power of 40 W.
ADJUSTMENT	NO

### 5.3.4 CRT intensity adjustment

TEST EQUIPMENT	NO
SETTING	Put the INTENS control at 10 o'clock.
ADJUSTMENT	Adjust VR3002 ("INTEN" - HOR PCB) for a just visible trace.

### 5.3.5 CRT focus adjustment

TEST EQUIPMENT	NO
SETTING	Put FOCUS control at centre position.
ADJUSTMENT	Adjust VR2011 ("FOCUS" - HOR PCB) for optimum brightness of the spot.

**5.3.6 CRT astigmatism adjustment**

TEST EQUIPMENT	NO
SETTING	Put FOCUS control at centre position.
ADJUSTMENT	Adjust VR2018 ("ASTIG" - HOR PCB) to make the spot a small circle.

**5.3.7 Vertical step balance adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - A Channel A coupling - GND Set MTB control for a fixed line.
ADJUSTMENT	Adjust VR15 ("STP" - VERT PCB) for minimum trace jump when switching the AMPL/DIV switch.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VR115.

**5.3.8 Vertical x5 MAG balance adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - A Channel A coupling - GND Set MTB control for a fixed line.
ADJUSTMENT	Adjust VR32 ("MAG" - VERT PCB) for minimum trace jump when pulling/pushing the variable control knob.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VR132.

**5.3.9 Vertical variable gain balance adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - A Channel A coupling - GND Set MTB control for a fixed line.
ADJUSTMENT	Adjust VR41 ("CH 1" - VERT PCB) for minimum vertical movement when turning the variable control knob.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VR141.

**5.3.10 Vertical gain**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - A Channel A coupling - DC Channel A AMPL/DIV - 0,1 V Channel A variable control in CAL. Apply a 1 kHz square-wave signal to channel A, peak to peak amplitude 500 mV.



**ADJUSTMENT** Adjust VR53 ("CH1G" - VERT PCB) for 5 divisions height.  
After adjustment, check the channel A variable gain control.  
With the control in minimum position, the waveform must decrease to less than 2 divisions.  
Switch back to position CAL.

**REQUIREMENTS** Check all positions of the AMPL/DIV switch.

<u>Input voltage</u>	<u>AMPL/DIV setting</u>	<u>display <math>\pm 3\%</math></u>
20 mV	5 mV	4 div
50 mV	10 mV	5 div
0,1 V	20 mV	5 div
0,2 V	50 mV	4 div
0,5 V	0,1 V	5 div
1 V	0,2 V	5 div
2 V	0,5 V	4 div
5 V	1 V	5 div
10 V	2 V	5 div
20 V	5 V	4 div

**SETTING** Vertical mode - B  
Channel B coupling - DC  
Channel B AMPL/DIV - 0,1 V  
Variable control in CAL.  
Apply a 1 kHz square-wave signal to channel B, peak to peak amplitude 500 mV.

**ADJUSTMENT** Adjust VR153 ("CH2G" - VERT PCB) for 5 divisions height.  
After adjustment, check the channel B variable gain control.  
With the control in minimum position, the waveform must decrease to less than 2 divisions.  
Switch back to position CAL.

**REQUIREMENTS** Check all AMPL/DIV steps of channel B as specified for A.

### 5.3.11 Vertical x5 MAG gain

**TEST EQUIPMENT** Square-wave calibration generator  
**SETTING** Vertical mode - A  
Channel A coupling - DC  
Channel A AMPL/DIV - 0,1 V  
Pull the channel A variable control into x5 position.  
Apply a 1 kHz square-wave signal to channel A, peak to peak amplitude 0,1 V.  
**ADJUSTMENT** Adjust VR30 ("x5G" - VERT PCB) for a waveform of 5 divisions.  
**SETTING** Repeat for channel B.  
**ADJUSTMENT** Repeat for channel B by means of VR130.

### 5.3.12 Channel B invert adjustment

**TEST EQUIPMENT** NO  
**SETTING** Vertical mode - DUAL  
Set for two straight lines A and B and place the two position knobs in centre position (12 o'clock). Check whether the knobs are correctly mounted at the axis (well centered).  
**ADJUSTMENT** Adjust VR148 ("POS CENT" - VERT PCB) in that way, that trace B does not move when switching the position knob to INVERT.  
After that, adjust VR332 for coincidence of trace B and the X-axis of the graticule. After that, adjust VR48 for coincidence of trace A and the X-axis of the graticule.

**5.3.13 ADD balance adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - DUAL Both channel A and B coupling - GND Set the A and B traces at the centre of the Y-axis.
REQUIREMENTS	Switch vertical mode to ADD. The trace must coincide with the X-axis of the graticule.
ADJUSTMENT	Adjust VR163 ("ADD" - VERT PCB) to move the trace.

**5.3.14 Low frequency response adjustment**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - A Channel A AMPL/DIV - 5 mV TIME/DIV - 0,2 $\mu$ s Apply a 1 MHz square-wave signal to channel A and set the amplitude at 5 div.
ADJUSTMENT	Adjust VR313 and VC312 ("MF" - VERT PCB) to make the line from rising edge to 0,2 $\mu$ s as flat as possible.

**5.3.15 High frequency response adjustment**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - A Channel A AMPL/DIV - 5 mV TIME/DIV - 0,2 $\mu$ s X MAGN - x10 Apply a 1 MHz square-wave signal to channel A and set the amplitude at 5 div.
ADJUSTMENT 1	Adjust VR47 and VC47 ("CH1" - VERT PCB) for minimum ringing and overshoot and the first 4 divisions as flat as possible.
ADJUSTMENT 2	Adjust VR25 and VC25 ("CH 1" - VERT PCB) for minimum ringing and overshoot and the first 2 divisions as flat as possible. As adjustment 1 and 2 are slightly interdependent, repeat some times for optimum results.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VR147-VC147 and VR125-VC125 ("CH 2" - VERT PCB).

**5.3.16 1 kHz square-wave response adjustment**

TEST EQUIPMENT	Square-wave calibration generator.
SETTING	Vertical mode - A Channel A AMPL/DIV - 0,1 V for adjustment 1, at 1 V for adjustment 2. Apply a 1 kHz square-wave signal to channel A and set the amplitude at 5 div.
REQUIREMENTS	Pulse aberrations must be $\leq 5\%$ .
ADJUSTMENT 1	Adjust VC5 (VERT PCB) for minimum over- and undershoot at AMPL/DIV - 0,1 V.
ADJUSTMENT 2	Adjust VC8 (VERT PCB) for minimum over- and undershoot at AMPL/DIV - 1 V.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VC105 and VC108 (VERT PCB).

**5.3.17 Input impedance adjustment**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - A Channel A AMPL/DIV - 5 mV Apply a 1 kHz square-wave signal to channel A via a 10 : 1 probe and set the amplitude at 5 div. Adjust the probe trimmer for a proper waveform. After that, set AMPL/DIV - 0,1 V for adjustment 1, at 1 V for adjustment 2.
REQUIREMENTS	Pulse aberrations must be $\leq 5\%$ .
ADJUSTMENT 1	Adjust VC4 (VERT PCB) for optimum waveform, AMPL/DIV -0,1 V.
ADJUSTMENT 2	Adjust VC7 (VERT PCB) for optimum waveform, AMPL/DIV - 1 V.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VC104 and VC107 (VERT PCB).

**5.3.18 Dual A and B, polarity inversion channel B**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - DUAL Both channel A and B coupling - DC Both channel A and B AMPL/DIV - 0,5 V TIME/DIV - 0,5 ms Apply a 1 kHz square-wave signal to both A and B and set for a trace height of 4 div.
REQUIREMENTS	Check whether A and B are displayed with the same polarity. Switch the channel B position switch to INVERT and check whether the polarity of waveform B is reversed.
ADJUSTMENT	NO

**5.3.19 ADD facility**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Vertical mode - DUAL Both channel A and B coupling - DC Both channel A and B AMPL/DIV - 0,5 mV TIME/DIV - 0,5 ms Apply a 1 kHz square-wave signal to both A and B and set for a trace height of 4 div.
REQUIREMENTS	Check whether A and B are displayed with the same polarity, waveform height 4 div. Press ADD and check that only one waveform of 8 div is shown. Switch channel B to INVERT and check that only one straight line is displayed.
ADJUSTMENT	NO

**5.3.20 Vertical bandwidth**

TEST EQUIPMENT SETTING	Constant amplitude sine-wave generator Vertical mode - A Channel A AMPL/DIV - 10 mV Apply a 50 kHz reference sine-wave signal to channel A and adjust the trace height to exactly 6 div.
REQUIREMENTS	Check that the trace height is $\geq 4,2$ div at 20 MHz.
SETTING AND REQUIREMENTS	Repeat for AMPL/DIV - 0,1 V.
SETTING AND REQUIREMENTS	Repeat for AMPL/DIV - 1 V.
ADJUSTMENT	NO
SETTING AND REQUIREMENTS	Repeat for channel B

**5.3.21 Trigger DC balance adjustment**

TEST EQUIPMENT SETTING	NO Vertical mode - A Channel A coupling - DC Trigger coupling - AC Apply the CAL signal to channel A and set for 2 div. Turn the trigger level, to position the trigger point at the centre of the rising edge.
ADJUSTMENT	Adjust VR73 ("TRIG DC" - VERT PCB) for minimum movement of the trigger point when switching the trigger coupling switch from AC to DC.
SETTING	Repeat for channel B.
ADJUSTMENT	Repeat for channel B by means of VR173 (VERT PCB).

**5.3.22 Y-out DC balance adjustment**

TEST EQUIPMENT SETTING	NO Vertical mode - A Channel A coupling - GND Channel A AMPL/DIV - 5 mV Set the trace at the centre of the Y-axis.
ADJUSTMENT	Adjust VR76 ("CH 1 OUT" - VERT PCB) for an output voltage at terminal YA-OUT (rear side) of 0 V at 50 $\Omega$ .

**5.3.23 Y-out gain adjustment**

TEST EQUIPMENT SETTING	NO Vertical mode - DUAL Both channel A and B coupling - DC Horizontal mode - MTB TIME/DIV - 0,2 ms Apply the CAL signal to channel A and set for 8 divisions. Connect the signal from the YA-OUT terminal at the rear side, termination 50 $\Omega$ , to channel B.
ADJUSTMENT	Adjust VR77 ("CH 1" - VERT PCB) for 8 divisions at channel B. Make sure that channel B is well calibrated.

**5.3.24 X-gain adjustment**

TEST EQUIPMENT	Square-wave calibration generator
SETTING	Channel A AMPL/DIV - 0,1 V Channel A coupling - DC Vertical mode - B TIME/DIV - X DEFL Trigger coupling - DC
ADJUSTMENT	Apply a 1 kHz square-wave signal, amplitude 0,5 V, to A. Adjust VR71 ("X-G" - VERT PCB) for an amplitude of 5 div.

**5.3.25 Triggering adjustment**

TEST EQUIPMENT	Function generator
SETTING	Vertical mode - A Horizontal mode - MTB TIME/DIV - 0,2 ms Triggering - AUTO Trigger coupling - DC Trigger level in centre position Apply a 1 kHz sine-wave signal to channel A and set for 8 divisions, well centered.
ADJUSTMENT	Adjust VR415 (HOR PCB) for minimum movement of the starting point of the trace when switching the level slope switch from + to — After that, adjust VR413 (HOR PCB) for coincidence of the starting point of the trace with the X-axis of the graticule.

**5.3.26 Trace starting point adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode A Horizontal mode - MTB TIME/DIV - 0,1 ms Triggering - AUTO Set X position knob in centre position.
ADJUSTMENT	Adjust the starting point of the trace at the beginning of the X-axis of the graticule by means of VR805 (HOR PCB).

**5.3.27 X-Y centering adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - B Channel A coupling - DC Channel B coupling - GND X position knob at centre position TIME/DIV - X DEFL
ADJUSTMENT	Adjust VR414 ("X-CENT" - HOR PCB) to position the spot at the centre of the X-axis.

**5.3.28 Horizontal bandwidth**

TEST EQUIPMENT SETTING	Constant amplitude sine-wave generator Channel A AMPL/DIV - 0,1 V Channel A coupling - DC Vertical mode - B Trigger coupling - DC Apply a 50 kHz reference sine-wave signal to channel A and set the amplitude at exactly 6 divisions.
REQUIREMENTS ADJUSTMENT	Check that the trace amplitude is $\geq 4,2$ div at 1 MHz. NO

**5.3.29 Z input**

TEST EQUIPMENT SETTING	Function generator Vertical mode - A Channel A coupling - GND Horizontal mode - MTB MTB TIME/DIV - 0,5 ms Triggering - AUTO Adjust for a line with normal brightness. Apply a 1 kHz square-wave signal with zero level of 0 V and positive level of 3 V to the Z input at the rear side of the instrument.
REQUIREMENTS	Note that parts of the time-base are blanked. Turn the MTB VAR knob if necessary.
ADJUSTMENT	NO

**5.3.30 MTB deflection coefficients**

TEST EQUIPMENT SETTING	Time-marker generator Vertical mode - A MTB TIME/DIV - 1 ms
ADJUSTMENT	Apply a 1 ms marker pulse to channel A. Adjust VR612 ("A-1ms" - HOR PCB) for coincidence of the marker pulses and the vertical graticule lines.
SETTING	MTB TIME/DIV - 1 $\mu$ s
ADJUSTMENT	Apply a 1 $\mu$ s marker pulse to channel A. Adjust VR613 ("A-1 $\mu$ s" - HOR PCB) for coincidence of the marker pulses and the vertical graticule lines.

REQUIREMENTS	Check all positions of the MTB TIME/DIV switch.		
	Marker input and MTB TIME/DIV	maximum coefficient error X MAGN x1    X MAGN x10 measured over central 8 div	
	0,2 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	0,5 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	1 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	2 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	5 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	10 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	20 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	50 $\mu$ s	$\pm 3 \%$	$\pm 5 \%$
	0,1 ms	$\pm 3 \%$	$\pm 5 \%$
	0,2 ms	$\pm 3 \%$	$\pm 5 \%$
	0,5 ms	$\pm 3 \%$	$\pm 5 \%$
	1 ms	$\pm 3 \%$	$\pm 5 \%$
	2 ms	$\pm 3 \%$	$\pm 5 \%$
	5 ms	$\pm 3 \%$	$\pm 5 \%$
	10 ms	$\pm 3 \%$	$\pm 5 \%$
	20 ms	$\pm 3 \%$	$\pm 5 \%$
	50 ms	$\pm 3 \%$	$\pm 5 \%$
	0,1 s	$\pm 3 \%$	$\pm 5 \%$
	0,2 s	$\pm 3 \%$	$\pm 5 \%$
	0,5 s	$\pm 3 \%$	$\pm 5 \%$

### 5.3.31 Sweep length adjustment

TEST EQUIPMENT	Time-marker generator
SETTING	Vertical mode - A Horizontal mode - MTB TIME/DIV - 0,1 ms
ADJUSTMENT	Apply a 0,1 ms marker pulse to channel A. Adjust VR614 (HOR PCB) for a sweep length of 11,5 divisions.

### 5.3.32 x10 MAG time adjustment

TEST EQUIPMENT	Time-marker generator
SETTING	Vertical input - A Horizontal input - MTB TIME/DIV - 1 ms X position switch at x10
ADJUSTMENT	Apply a 0,1 ms marker pulse to channel A. Adjust VR807 (HOR PCB) for coincidence of the marker pulse with the graticule lines.

**5.3.33 x10 MAG centre balance adjustment**

TEST EQUIPMENT	NO
SETTING	Vertical mode - A TIME/DIV - 0,1 ms Apply the CAL signal to channel A and set for 2 divisions. Set the trailing edge at the centre of the X-axis.
ADJUSTMENT	Pull X MAGN x10, without turning the knob and adjust VR806 ("MAG CENT" - HOR PCB) for minimum movement of the trailing edge.



## 6 DISMANTLING THE INSTRUMENT

### 6.1 GENERAL INFORMATION

**WARNING:** The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.  
The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened.  
If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved.  
Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.

**ATTENTION:** *This section provides the dismantling procedures required for the removal of components during repair operations. All circuit boards removed from the oscilloscope should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed.*  
*During dismantling procedures, a careful note must be made of all disconnected leads, to ensure that they may be reconnected to their correct terminals during assembly.*  
*Damage may result if the instrument is switched on when a circuit board has been removed, or if a circuit board is removed within one minute after switching off the instrument.*

**NOTE:** *All screws which have to be remounted directly in the housing-parts must be fixed with a torque of maximum 1 Nm.*

### 6.2 REMOVING THE TOP- AND BOTTOM COVERS

To adjust the instrument it is necessary to remove both the top- and bottom covers.

#### 6.2.1 Removing the top cover

- remove the 6 mounting screws, 3 left, 3 right, 2 on the top (fig. 6.1)
- now the top cover can be lifted vertically.

#### 6.2.2 Removing the bottom cover

- remove the 8 mounting screws, 1 left, 1 right, 6 on the bottom.
- now, the bottom cover can be lifted vertically.

#### 6.2.3 Remounting the covers.

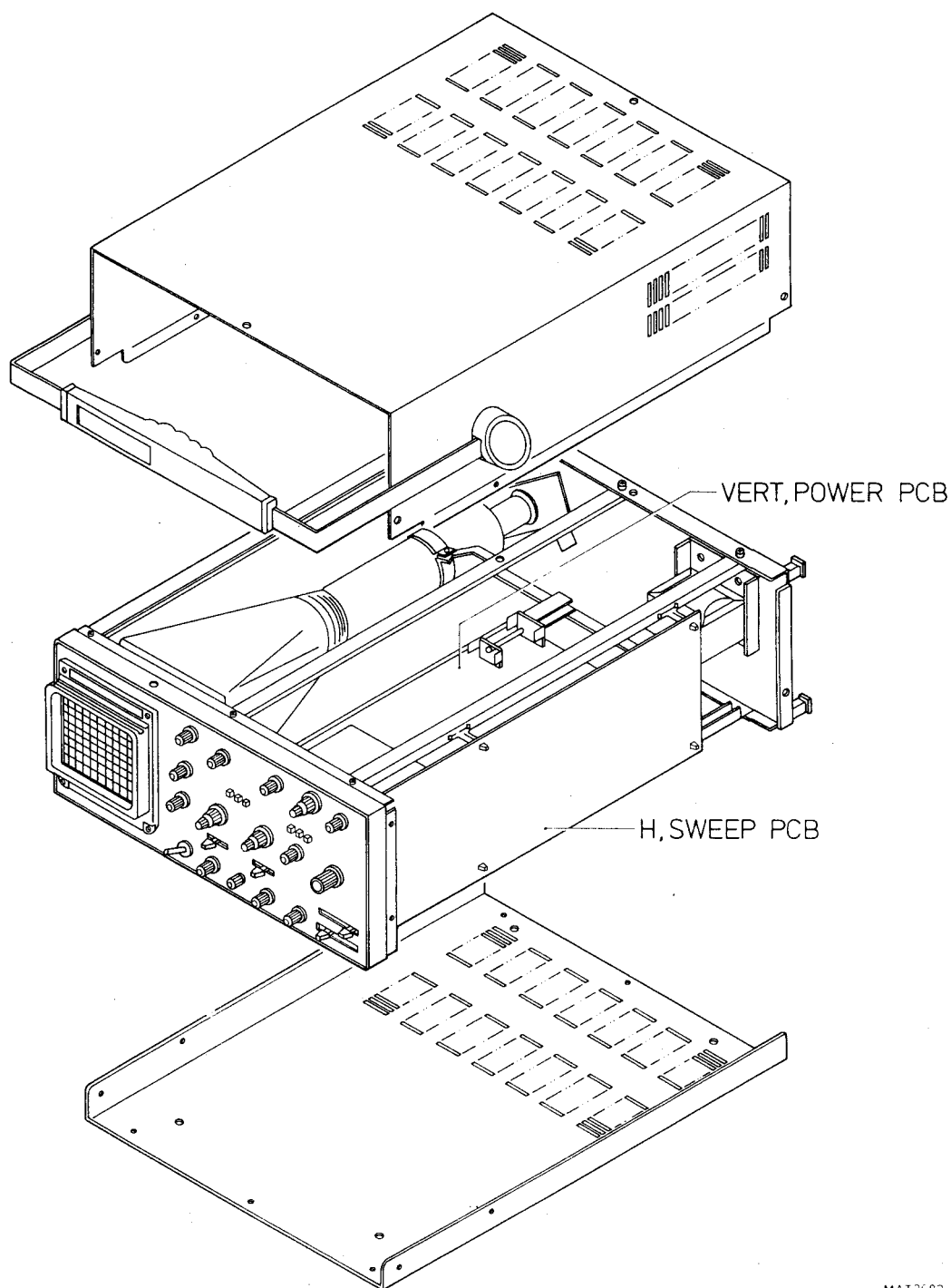
Remounting the covers can be carried out in reversed order.

### 6.3 ACCESS TO PARTS FOR CHECKING AND ADJUSTING PROCEDURE

All adjusting elements, except the trace rotation, are accessible after removing the top- and bottom covers.

The trace rotation is accessible from the front

*NOTE: For adjustment always use an insulated adjustment tool.*



MAT3/83  
8905/12

Figure 6.1 Dismantling the instrument

## 7 CORRECTIVE MAINTENANCE

### 7.1 REPLACEMENTS

**WARNING:** The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.  
The instruments shall be disconnected from all voltage sources before any adjustment, replacement or maintenance or repair during which the instrument will be opened.  
If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved.  
Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.

#### 7.1.1 Standard parts

Electrical and mechanical replacement parts can be obtained through your local Philips organisation or representative. However, many of the standard electronic components can be obtained from other local suppliers.  
Before purchasing or ordering replacement parts, check the parts list for value tolerance, rating and description.

*NOTE: Physical size and shape of a component may affect instrument performance, particularly at high frequencies. Always use direct-replacement components, unless it is known that a substitute will not degrade instrument performance.*

#### 7.1.2 Special parts

In addition to the standard electronic components, some special components are used.

- Components manufactured or selected by Philips to meet specific performance requirements.
- Components which are important for the safety of the instrument.

#### 7.1.3 Transistors and integrated circuits

Transistors and IC's (integrated circuits) should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement or exchanging of semiconductor devices may affect the calibration of the instrument. When a transistor is replaced, check the operation of the part of the instrument that may be affected.

**WARNING:** Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

Any replacement component should be of the original type or a direct replacement.

## 7.2 REMOVING AND REMOUNTING THE UNITS

### 7.2.1 Removing the vertical PCB

- Remove all connectors from the PCB.  
Make sure that afterwards the connectors will be replaced correctly.
- Desolder the white twin-lead cable at the component side of the PCB.
- Desolder the 2 brown wires and the 4 uninsulated wires to the input coupling switches (fig. 7.1).
- Unscrew the 6 yellow-green wires at the soldering side of the PCB (fig. 7.1).
- Unscrew the 2 knobs from the AMPL/DIV variable controls and those from the AMPL/DIV switches by means of a hex screwdriver, size 1,5 mm, and remove them.
- Unscrew the 2 AMPL/DIV switches by means of a pick-lock, size 11 mm.
- Unscrew the copper plate which is fixed at the frame (fig. 7.1).
- Loosen the 4 plastic supports (fig. 7.1) by means of a PCB snapper.
- Now, the PCB can be removed.
- Remounting the PCB can be carried out in reversed order.

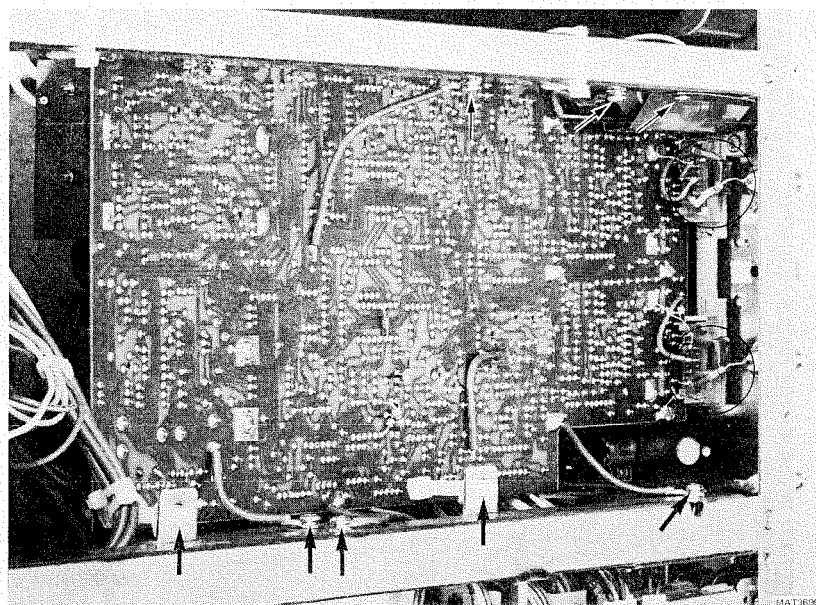


Figure 7.1 Removing vertical pcb

### 7.2.2 Removing the horizontal PCB

- Remove all connectors from the PCB.  
Make sure that afterwards the connectors will be replaced correctly.
- Unscrew the yellow-green wire which is fixed at the frame (fig. 7.1).
- Unsolder the brown wire from EXT-BNC connector to PCB.
- Unsolder the red and brown wires from CRT socket to PCB.
- Remove the 2 knobs from trigger coupling and trigger source by pulling them.
- Unscrew the knob from the MTB switch by means of a hex screwdriver, size 1,5 mm, and remove it.
- Unscrew the TIME/DIV switch by means of a pick-lock, size 11 mm.
- Remove the screw which fixes the high voltage protection cover at the frame (fig. 7.1).
- Remove the 4 screws which fix the PCB (fig. 7.2).
- Now, the PCB can be removed.
- Remounting the PCB can be carried out in reversed order.

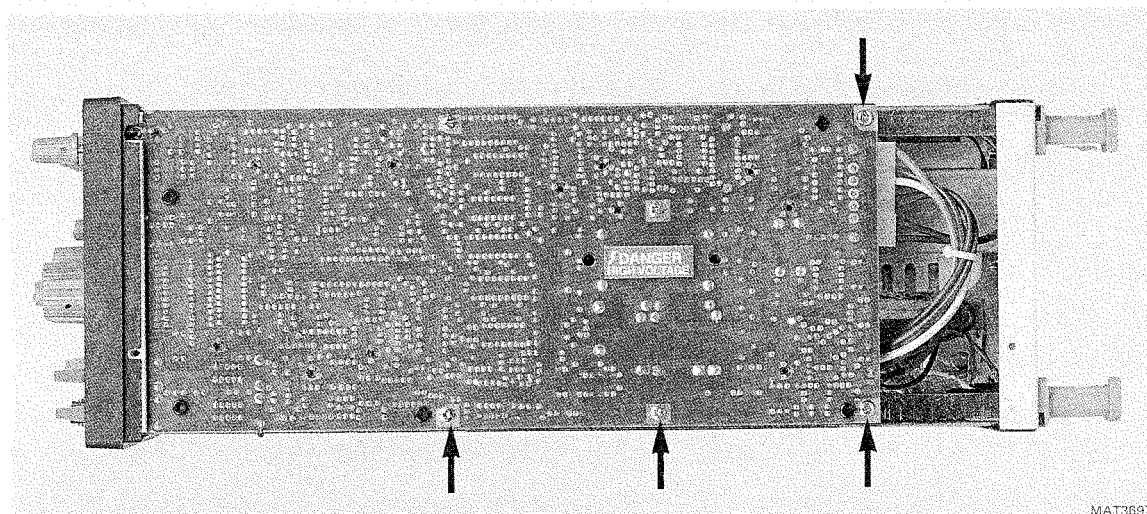


Figure 7.2 Removing horizontal pcb

### 7.2.3 Removing the cal and control PCB

- Remove all connectors from the PCB.  
Make sure that afterwards the connectors will be replaced correctly.
- Remove the knobs INTENS, FOCUS and ILLUM, by pulling them firmly.
- Unscrew these controls by means of a pick-lock, size 11 mm.
- Unscrew the copper plate between frame and CRT (fig. 7.3).  
Make sure that afterwards this plate will be remounted correctly.
- Now, the PCB can be removed.
- Remounting the PCB can be carried out in reversed order.

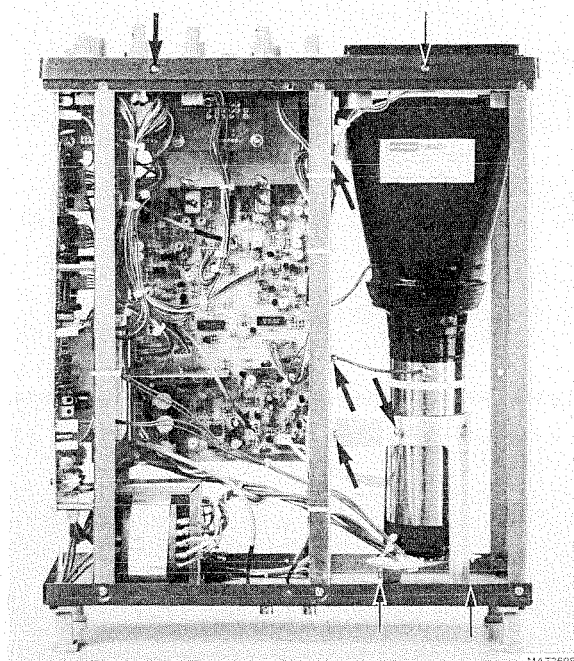


Figure 7.3 Removing cal and control pcb

#### 7.2.4 Removing the mode PCB

- Remove all connectors from the PCB.  
Make sure that afterwards the connectors will be replaced correctly.
- Remove the 4 screws from the plastic rim around the front (fig. 7.3) and remove the rim.
- Remove the knobs X POS, POS A and POS B, by pulling them firmly.
- Remove the 3 position potmeters by means of a pick-lock, size 11 mm.
- Remove the 5 screws from the PCB (fig. 7.4).
- Now, the PCB can be removed.
- Remounting the PCB can be carried out in reversed order.

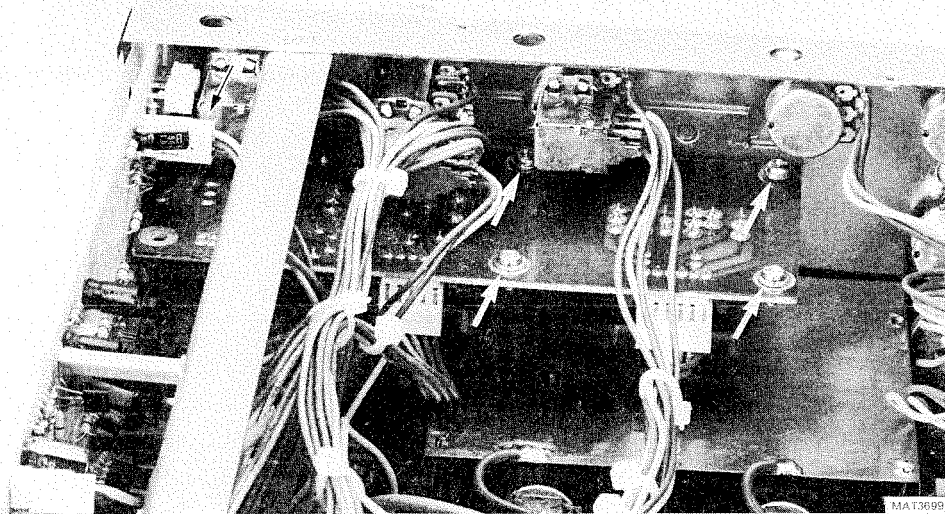


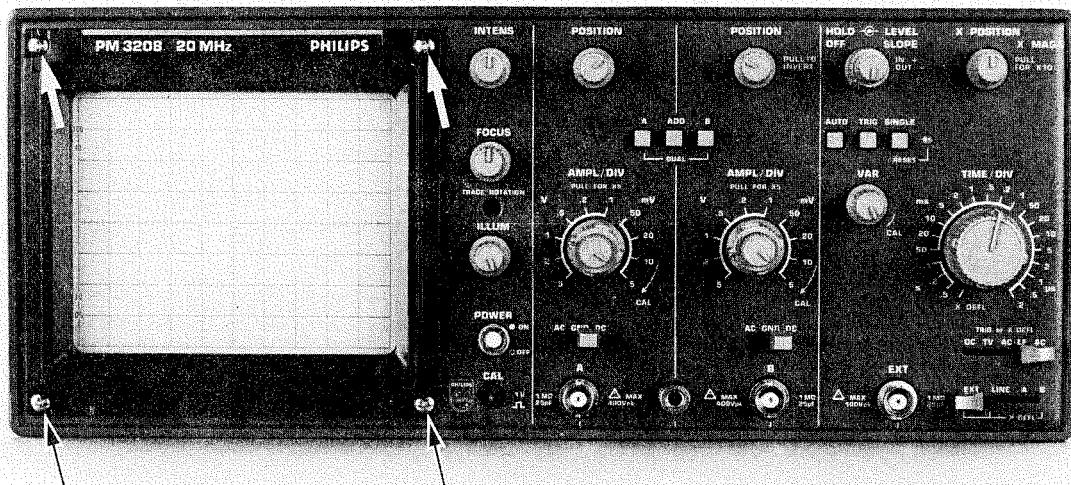
Figure 7.4 Removing mode pcb

#### 7.2.5 Removing the CRT

- Remove the PCB from the CRT connector.
- Unscrew the yellow-green wire from the frame (fig. 7.3).
- Remove the 2-pole connector of the trace rotation coil (brown and red wires) from the CAL and CONTROL PCB.
- Remove the 2 screws from the clamp around the CRT (fig. 7.3).
- Remove the 2 screws by which the CRT clamp is fixed at the frame and remove the 2 parts of the clamp (fig. 7.3).
- Now, the CRT can be removed by gently pulling it from the front.
- Remounting the CRT can be carried out in reversed order.

### 7.2.6 Replacing the text plate

- Remove the 4 screws from the bezel (fig. 7.5).
- Remove the bezel.
- Remove all knobs. Some knobs are fixed by a screw; first remove the screw by means of a hex screwdriver, size 1,5 mm.
- Remove the 4 screws from the plastic rim around the front (fig 7.3) and remove the rim.
- Now, the text plate can be removed from the front plate by pulling it off; the text plate has been fixed by means of sticking-strip.
- Now, a new text plate can be mounted.
- Replace knobs and bezel.
- Check whether the knobs have been placed onto the shafts in the right position.



MAT3700

Figure 7.5 Removing text plate

## 8 SAFETY INSPECTION AND TEST AFTER REPAIR IN THE PRIMARY CIRCUIT

### 8.1 GENERAL DIRECTIVES

- Take care that the creepage distances and clearances have not been reduced.
- Before soldering, the wires should be bent through the holes of solder tags, or wrapped around the tag in the form of an open U, or, wiring rigidity shall be maintained by cable clamps or cable lacing.
- Replace all insulating guards and -plates.

### 8.2 SAFETY COMPONENTS

Components in the primary circuit may only be renewed by components selected by Philips, see also section 7.1.2.

### 8.3 CHECKING THE PROTECTIVE EARTH CONNECTION

The correct connection and condition is checked by visual checking and by measuring the resistance between the protective lead connection at the plug and the cabinet/frame. The resistance shall not be more than 0,1  $\Omega$ . During measurement the mains cable should be removed from the mains. Resistance variations indicate a defect.

### 8.4 CHECKING THE INSULATION RESISTANCE

Measure the insulation resistance at  $U = 500 \text{ V (dc)}$  between the mains connections and the protective lead connections. For this purpose, set the mains switch to ON. The insulation resistance shall not be less than 2 M $\Omega$ .

*NOTE: 2 M $\Omega$  is a minimum requirement at 40 °C and 95 % relative humidity. Under normal conditions the insulation resistance should be much higher (10...20 M $\Omega$ ).*

### 8.5 CHECKING THE LEAKAGE CURRENT

The leakage current shall be measured between each pole of the mains supply in turn, and all accessible conductive parts connected together (including the measuring earth terminal).

The leakage current is not excessive if the measured currents from the mentioned parts do not exceed 0,5 mA (rms).



## 8.6 VOLTAGE TEST

The instrument shall withstand, without electrical breakdown, the application of a test voltage between the supply circuit and accessible conductive parts that are likely to become energized. The test potential shall be 1500 V (rms) at supply circuit frequency, applied for one second.

The test shall be conducted when the instrument is fully assembled, and with the primary switch in the ON position.

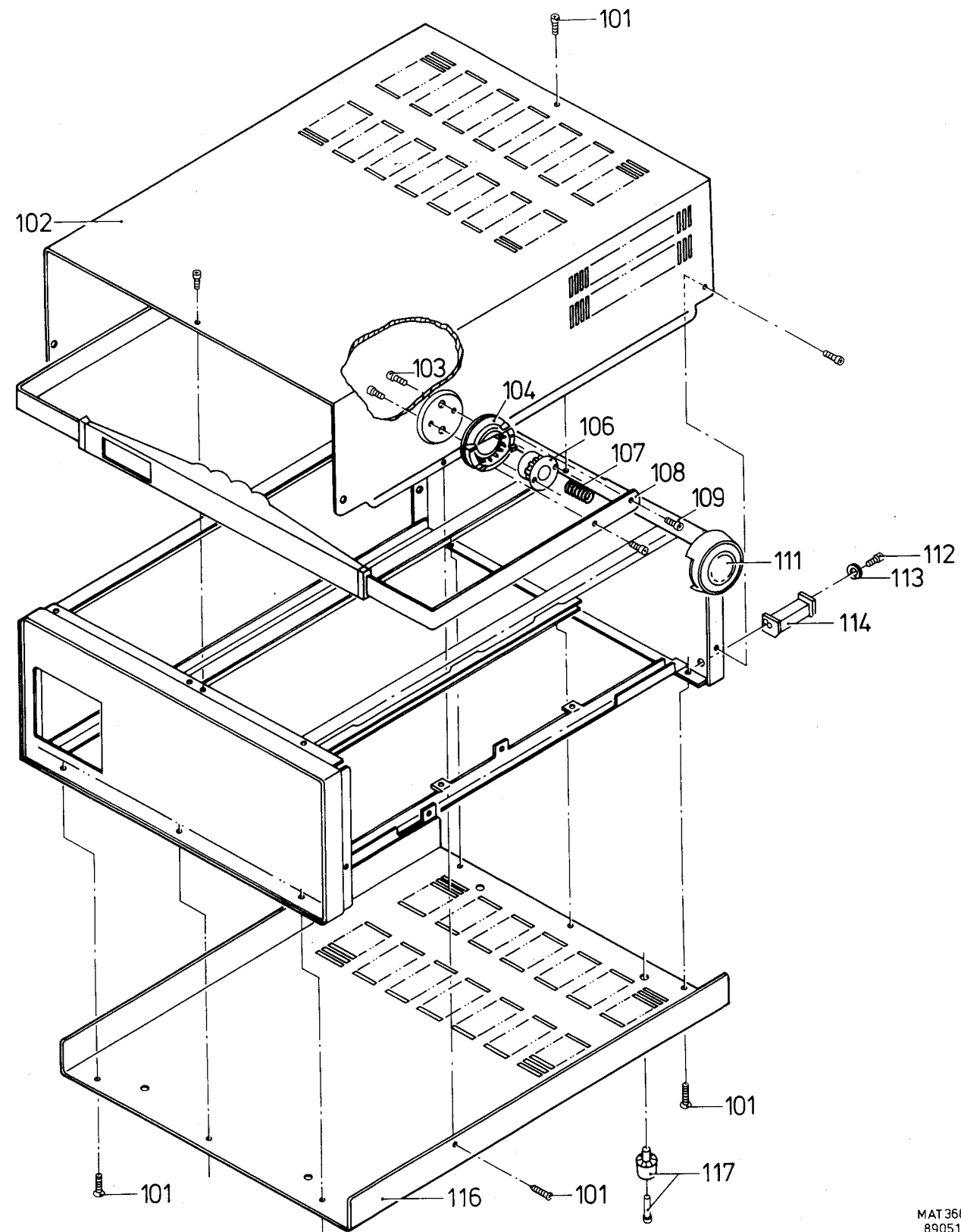
During the test, both sides of the primary circuit of the instrument are connected together and to one terminal of the voltage test equipment; the other voltage test equipment terminal is connected to the accessible conductive parts.

## **9 PARTSLIST**

### **9.1 MECHANICAL PARTS**

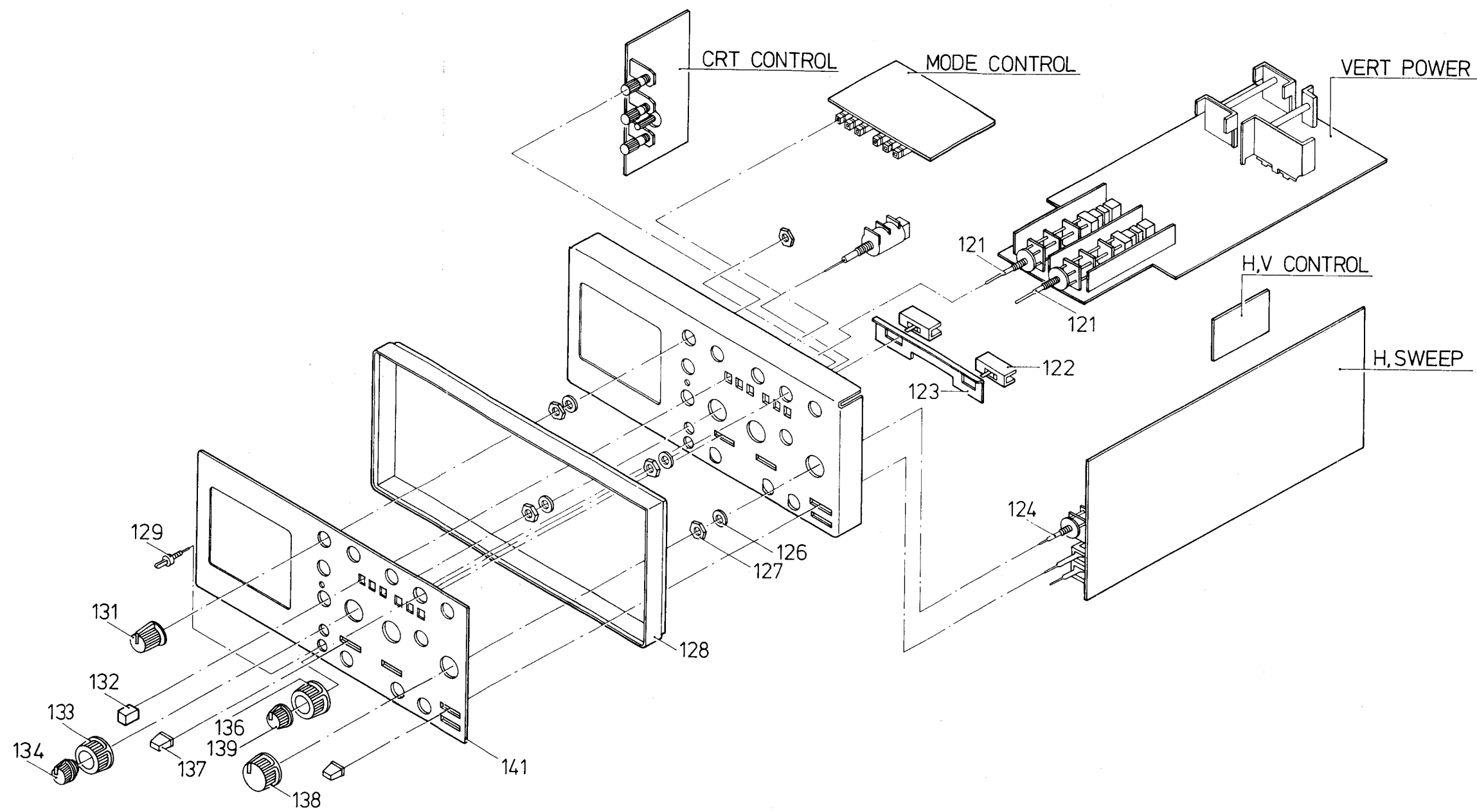
All mechanical parts of this instrument can be found on figures 9.1, 9.2 and 9.3.  
For ordering codes, see the following pages.

POS NR	ORDERING CODE	DESCRIPTION
102	5322 447 91721	UPPER CASE
104	5322 401 11297	HANDLE BRACKET
106	5322 401 11298	HANDLE FIX BRACKET
107	5322 492 42425	HANDLE SPRING
108	5322 498 50274	HANDLE ASSY
111	5322 498 70092	HANDLE COVER
114	5322 498 70093	CORD REST
116	5322 447 91722	LOWER CASE
117	5322 529 10248	PLASTIC LEG



MAT3680  
890512

Figure 9.1 Housing



MAT3584  
890512

Figure 9.2 Front panel

<u>POS NR</u>	<u>ORDERING CODE</u>	<u>DESCRIPTION</u>
121	5322 273 10185	VERT ROTARY SWITCH
122	5322 277 21333	SLIDE SWITCH
123	5322 401 11295	BRACKET SLIDE SWITCH (1)
124	5322 273 10186	TIME ROTARY SWITCH
128	5322 460 60512	FRONT FRAME
129	5322 290 60833	CAL TERMINAL
131	5322 414 30154	KNOB (1)
132	5322 414 10056	KNOB (8)
133	5322 414 30157	KNOB (4)
134	5322 414 30158	KNOB (5)
136	5322 414 30155	KNOB (2)
137	5322 414 10055	KNOB (7)
138	5322 414 30159	KNOB (6)
139	5322 414 30156	KNOB (3)
141	5322 447 91725	TOP PLATE

POS NR	ORDERING CODE	DESCRIPTION
152	5322 401 11296	POWER SWITCH BRACKET
153	5322 276 12634	POWER SWITCH
154	5322 535 92943	SHAFT-1
158	5322 255 40985	HEATSINK-2A
159	5322 255 40987	HEATSINK-3
163	5322 267 10227	BNC TERMINAL
166	5322 535 92942	POWER SWITCH BAR
167	5322 532 21383	JOINT METAL
169	5322 460 60511	FRAME (6)
171	5322 255 40986	HEATSINK-2B
172	5322 447 91718	REAR PANEL
173	5322 460 60511	FRAME (1)
174	5322 414 10057	KNOB (13)
176	5322 414 10058	KNOB (14)
177	5322 460 60509	FRAME (2)
179	5322 255 40984	HEATSINK-1B
183	5322 466 30327	SHIELD PLATE
184	5322 255 40983	HEATSINK-1A
186	5322 535 92944	SHAFT-2
187	5322 464 60063	CRT FRAME (2)
188	5322 256 91527	CRT HOLDER (4)
189	5322 255 40981	CRT SOCKET
191	5322 535 92945	LOCKING SPACER
193	5322 447 91723	CRT GROUND PLATE
194	5322 255 40982	CRT HOLDER (3)
197	5322 256 30422	FUSE HOLDER
199	5322 466 30326	CRT SHIELD
201	5322 447 91719	FRONT PANEL
204	5322 464 60059	FRAME (3)
207	5322 290 60832	CRT EARTH PANEL
208	5322 464 60062	FRAME (5)
209	5322 464 60061	FRAME (4)
211	5322 498 50275	PCB GRIP
212	5322 480 20112	FILTER
213	5322 290 60834	GND TERMINAL
217	5322 455 81089	NAME PLATE
218	5322 460 60512	BEZEL
219	5322 450 30473	SCALE

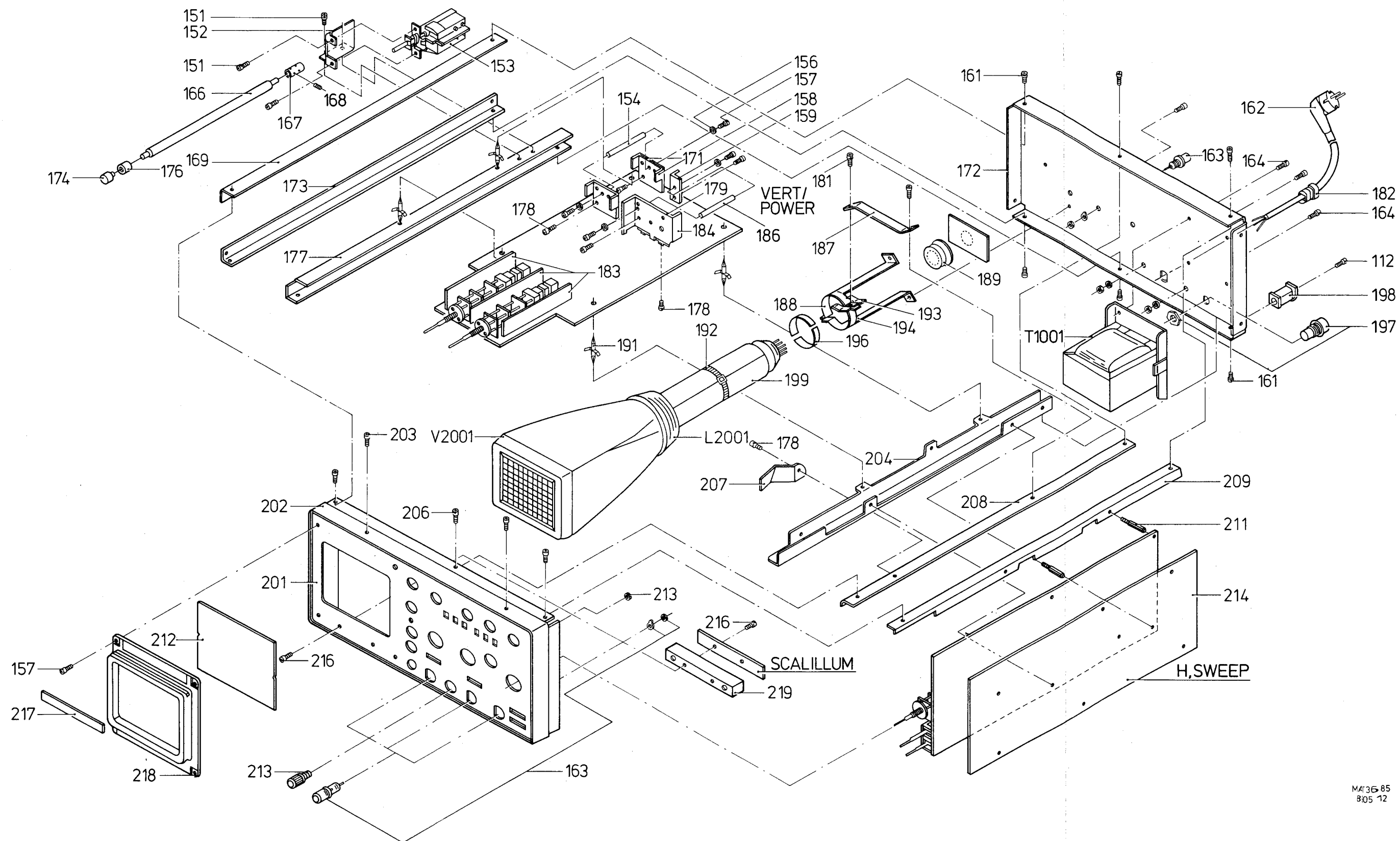


Figure 9.3 Main frame



**9.2 UNITS**

POS NR	ORDERING CODE	DESCRIPTION
A0001	5322 216 51248	VERTICAL PCB ASSY
A0002	5322 216 51247	HORIZONTAL PCB ASSY
A0003	5322 216 51244	CAL & CONTROL PCB ASSY
A0004	5322 216 51249	MODE PCB ASSY
A0005	5322 216 51251	CRT PCB ASSY

**9.3 CABLES AND CONNECTORS**

POS NR	ORDERING CODE	DESCRIPTION
CN0001-J	5322 268 40233	CONNECTOR JACK 3P
CN0001-P	5322 265 30433	CONNECTOR PLUG 3P
CN0002-J	5322 268 40233	CONNECTOR JACK 3P
CN0002-P	5322 265 30433	CONNECTOR PLUG 3P
CN0101-J	5322 268 40279	CONNECTOR JACK 5P
CN0101-P	5322 265 30529	CONNECTOR PLUG 5P
CN0102-J	5322 268 40233	CONNECTOR JACK 3P
CN0102-P	5322 265 30433	CONNECTOR PLUG 3P
CN0201-J	5322 268 40233	CONNECTOR JACK 3P
CN0201-P	5322 265 30433	CONNECTOR PLUG 3P
CN0202-J	5322 268 40301	CONNECTOR JACK 6P
CN0202-P	5322 265 30741	CONNECTOR PLUG 6P
CN0203-J	5322 268 40269	CONNECTOR JACK 4P
CN0203-P	5322 265 30533	CONNECTOR PLUG 4P
CN0301-J	5322 268 40233	CONNECTOR JACK 3P
CN0301-P	5322 265 30433	CONNECTOR PLUG 3P
CN0402-J	5322 268 40269	CONNECTOR JACK 4P
CN0402-P	5322 265 30533	CONNECTOR PLUG 4P
CN0403-J	5322 268 40279	CONNECTOR JACK 5P
CN0403-P	5322 265 30529	CONNECTOR PLUG 5P
CN0406-J	5322 268 40301	CONNECTOR JACK 6P
CN0406-P	5322 265 30741	CONNECTOR PLUG 6P
CN0601-J	5322 268 40279	CONNECTOR JACK 5P
CN0601-P	5322 265 30529	CONNECTOR PLUG 5P
CN0602-J	5322 268 40233	CONNECTOR JACK 3P
CN0602-P	5322 265 30433	CONNECTOR PLUG 3P
CN0603-J	5322 268 40233	CONNECTOR JACK 3P
CN0603-P	5322 265 30433	CONNECTOR PLUG 3P
CN0702-J	5322 268 40269	CONNECTOR JACK 4P
CN0702-P	5322 265 30533	CONNECTOR PLUG 4P
CN0801-J	5322 268 40233	CONNECTOR JACK 3P
CN0801-P	5322 265 30433	CONNECTOR PLUG 3P
CN0802-J	5322 268 40233	CONNECTOR JACK 3P
CN0802-P	5322 265 30433	CONNECTOR PLUG 3P
CN1001-J	5322 268 40279	CONNECTOR JACK 5P
CN1001-P	5322 265 30529	CONNECTOR PLUG 5P
CN1002-J		CONNECTOR JACK 8P
CN1002-P	5322 265 40919	CONNECTOR PLUG 8P
CN1003-J	5322 268 40233	CONNECTOR JACK 3P
CN1003-P	5322 265 30433	CONNECTOR PLUG 3P
CN1004-J	5322 268 40279	CONNECTOR JACK 5P
CN1004-P	5322 265 30529	CONNECTOR PLUG 5P

POS NR	ORDERING CODE	DESCRIPTION
CN1005-J	5322 268 40301	CONNECTOR JACK 6P
CN1005-P	5322 265 30741	CONNECTOR PLUG 6P
CN2001-J	5322 268 40233	CONNECTOR JACK 3P
CN2001-P	5322 265 30433	CONNECTOR PLUG 3P
CN2002-J	5322 268 40279	CONNECTOR JACK 5P
CN2002-P	5322 265 30529	CONNECTOR PLUG 5P
CN2003-J	5322 268 40301	CONNECTOR JACK 6P
CN2003-P	5322 265 30741	CONNECTOR PLUG 6P
CN2004/2-J		CONNECTOR JACK 2P
CN2004/2-P		CONNECTOR PLUG 2P
CN2004/5-J		CONNECTOR JACK 5P
CN2004/5-P		CONNECTOR PLUG 5P
CN2006-J	5322 268 40233	CONNECTOR JACK 3P
CN2006-P	5322 265 30433	CONNECTOR PLUG 3P
CN3001-J	5322 268 40233	CONNECTOR JACK 3P
CN3001-P	5322 265 30433	CONNECTOR PLUG 3P
CN3002-J	5322 268 40269	CONNECTOR JACK 4P
CN3002-P	5322 265 30533	CONNECTOR PLUG 4P
CN4001-J	5322 268 40232	CONNECTOR JACK 2P
CN4001-P	5322 265 20275	CONNECTOR PLUG 2P

## 9.4 ELECTRICAL PARTS

### 9.4.1 Special capacitors

POS NR	ORDERING CODE	DESCRIPTION
C0002	5322 124 41788	METALFILM CAPACITOR 22 nF - 630 V
C0012	5322 124 41791	POLYPROP CAPACITOR 2,2 nF - 400 V
C0102	5322 124 41788	METALFILM CAPACITOR 22 nF - 630 V
C0112	5322 124 41791	POLYPROP CAPACITOR 2,2 nF - 400 V
C0310	5322 124 41787	METALFILM CAPACITOR 10 nF - 100 V
C0311	5322 124 41787	METALFILM CAPACITOR 10 nF - 100 V
C0317	5322 124 41788	METALFILM CAPACITOR 22 nF - 630 V
C0318	5322 124 41788	METALFILM CAPACITOR 22 nF - 630 V
C0319	5322 124 41793	POLYPROP CAPACITOR 47 nF - 100 V
C0320	5322 124 41789	METALFILM CAPACITOR 47 nF - 250 V
C0321	5322 124 41789	METALFILM CAPACITOR 47 nF - 250 V
C0429	5322 124 14075	TANTAL CAPACITOR 1 $\mu$ F - 35 V
C0607	5322 124 41785	METALFILM CAPACITOR 1 nF - 100 V
C0608	5322 124 41786	METALFILM CAPACITOR 1 $\mu$ F - 100 V
C1000	5322 122 50111	CERAMIC CAPACITOR 2,2 nF - 1 kV
C1024	5322 124 41792	POLYPROP CAPACITOR 22 nF - 100 V
C1025	5322 124 41792	POLYPROP CAPACITOR 22 nF - 100 V
C2002	5322 124 14075	TANTAL CAPACITOR 1 $\mu$ F - 35 V
C2010	5322 122 50114	CERAMIC CAPACITOR 4,7 nF - 3 kV
C2011	5322 122 50114	CERAMIC CAPACITOR 4,7 nF - 3 kV
C2012	5322 122 50114	CERAMIC CAPACITOR 4,7 nF - 3 kV
C2014	5322 122 50114	CERAMIC CAPACITOR 4,7 nF - 3 kV
C2015	5322 122 50112	CERAMIC CAPACITOR 22 pF - 2 kV
C3014	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV
C3015	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV
C3017	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV
C3018	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV
C3022	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV
C3023	5322 122 50113	CERAMIC CAPACITOR 1 nF - 6 kV

**9.4.2 Trimmer capacitors**

POS NR	ORDERING CODE	DESCRIPTION	
VC0004	5322 125 11038	TRIMMER CAPACITOR	10 pF
VC0005	5322 125 11037	TRIMMER CAPACITOR	6 pF
VC0007	5322 125 11038	TRIMMER CAPACITOR	10 pF
VC0008	5322 125 11037	TRIMMER CAPACITOR	6 pF
VC0025	5322 125 11039	TRIMMER CAPACITOR	30 pF
VC0047	5322 125 11041	TRIMMER CAPACITOR	50 pF
VC0104	5322 125 11038	TRIMMER CAPACITOR	10 pF
VC0105	5322 125 11037	TRIMMER CAPACITOR	6 pF
VC0107	5322 125 11038	TRIMMER CAPACITOR	10 pF
VC0108	5322 125 11037	TRIMMER CAPACITOR	6 pF
VC0125	5322 125 11039	TRIMMER CAPACITOR	30 pF
VC0147	5322 125 11041	TRIMMER CAPACITOR	50 pF
VC0312	5322 125 11039	TRIMMER CAPACITOR	30 pF

**9.4.3 Special resistors**

POS NR	ORDERING CODE	DESCRIPTION	
R0020	5322 116 30374	THERMISTOR	250 $\Omega$ $\pm$ 10 %
R0072	5322 116 30374	THERMISTOR	250 $\Omega$ $\pm$ 10 %
R0120	5322 116 30374	THERMISTOR	250 $\Omega$ $\pm$ 10 %
R0315	4822 116 52618	METAL OXID RESISTOR	33 k $\Omega$ - 1 W
R0316	4822 116 52618	METAL OXID RESISTOR	33 k $\Omega$ - 1 W
R0320	4822 116 52627	METAL OXID RESISTOR	47 k $\Omega$ - 1 W
R0321	4822 116 52627	METAL OXID RESISTOR	47 k $\Omega$ - 1 W
R0411	4822 116 52627	METAL OXID RESISTOR	47 k $\Omega$ - 1 W
R1001	4822 116 60252	METAL OXID RESISTOR	1 $\Omega$ - 1 W
R1003	4822 116 51098	METAL OXID RESISTOR	100 $\Omega$ - 1 W
R1009	4822 116 51098	METAL OXID RESISTOR	100 $\Omega$ - 1 W
R1014	4822 116 55227	METAL OXID RESISTOR	1,2 k $\Omega$ - 2 W
R1026	4822 116 51098	METAL OXID RESISTOR	100 $\Omega$ - 1 W
R2008	4822 116 60252	METAL OXID RESISTOR	1 $\Omega$ - 1 W
R2012	5322 116 64007	METAL GLAZE RESISTOR	10 M $\Omega$ - 1 W
R3021	4822 110 42214	SOLID RESISTOR	10 M $\Omega$ - 0,5 W
R3022	4822 110 42214	SOLID RESISTOR	10 M $\Omega$ - 0,5 W
R3024	4822 110 42214	SOLID RESISTOR	10 M $\Omega$ - 0,5 W
R3025	4822 110 42214	SOLID RESISTOR	10 M $\Omega$ - 0,5 W
RN201	5322 111 91796	RESISTOR NETWORK	4 x 10 k $\Omega$
RN701	5322 111 91796	RESISTOR NETWORK	4 x 10 k $\Omega$

**9.4.4 Trimmer resistors**

POS NR	ORDERING CODE	DESCRIPTION	
VR0015	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0025	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0030	5322 103 60083	TRIMMER RESISTOR	100 $\Omega$
VR0032	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0041	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0047	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0048	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0053	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$

POS NR	ORDERING CODE	DESCRIPTION	
VR0071	5322 103 60083	TRIMMER RESISTOR	100 $\Omega$
VR0073	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR0076	5322 103 60086	TRIMMER RESISTOR	2 k $\Omega$
VR0077	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR0115	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0125	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0130	5322 103 60083	TRIMMER RESISTOR	100 $\Omega$
VR0132	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0141	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0147	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0148	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0153	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR0163	5322 103 60084	TRIMMER RESISTOR	500 $\Omega$
VR0173	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR0313	5322 103 60086	TRIMMER RESISTOR	2 k $\Omega$
VR0332	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0413	5322 103 60087	TRIMMER RESISTOR	5 k $\Omega$
VR0414	5322 103 60087	TRIMMER RESISTOR	5 k $\Omega$
VR0415	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR0612	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0613	5322 103 60091	TRIMMER RESISTOR	500 k $\Omega$
VR0614	5322 103 60087	TRIMMER RESISTOR	5 k $\Omega$
VR0805	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$
VR0806	5322 103 60087	TRIMMER RESISTOR	5 k $\Omega$
VR0807	5322 103 60083	TRIMMER RESISTOR	100 $\Omega$
VR1006	5322 103 60085	TRIMMER RESISTOR	1 k $\Omega$
VR2011	5322 103 60092	TRIMMER RESISTOR	2 M $\Omega$
VR2018	5322 103 60089	TRIMMER RESISTOR	100 k $\Omega$
VR3002	5322 103 60088	TRIMMER RESISTOR	20 k $\Omega$

#### 9.4.5 Potentiometers

POS NR	ORDERING CODE	DESCRIPTION	
RV0039	5322 101 40149	POTENTIOMETER	1 k $\Omega$
RV0054	5322 101 40154	POTENTIOMETER	10 k $\Omega$
RV0139	5322 101 40149	POTENTIOMETER	1 k $\Omega$
RV0154	5322 101 40152	POTENTIOMETER	10 k $\Omega$
RV0441	5322 101 40155	POTENTIOMETER	10 k $\Omega$ + 100 k $\Omega$
RV0614	5322 101 40153	POTENTIOMETER	10 k $\Omega$
RV0801	5322 101 40152	POTENTIOMETER	10 k $\Omega$
RV3033	5322 101 40151	POTENTIOMETER	10 k $\Omega$
RV3035	5322 101 40157	POTENTIOMETER	200 k $\Omega$
RV3036	5322 101 40156	POTENTIOMETER	2 k $\Omega$
RV3037	5322 101 40151	POTENTIOMETER	10 k $\Omega$

#### 9.4.6 Diodes

POS NR	ORDERING CODE	DESCRIPTION
D0001	5322 130 61739	TRANSISTOR 2SC1907
D0059	4822 130 81619	DIODE HZ3C-2
D0060	4822 130 31537	DIODE 1S1588
D0061	4822 130 31537	DIODE 1S1588

POS NR	ORDERING CODE	DESCRIPTION
D0062	4822 130 31537	DIODE 1S1588
D0063	4822 130 31537	DIODE 1S1588
D0075	4822 130 31537	DIODE 1S1588
D0076	4822 130 31537	DIODE 1S1588
D0077	4822 130 31537	DIODE 1S1588
D0101	5322 130 61739	TRANSISTOR 2SC1907
D0159	4822 130 81619	DIODE HZ3C-2
D0160	4822 130 31537	DIODE 1S1588
D0161	4822 130 31537	DIODE 1S1588
D0162	4822 130 31537	DIODE 1S1588
D0163	4822 130 31537	DIODE 1S1588
D0175	4822 130 31537	DIODE 1S1588
D0176	4822 130 31537	DIODE 1S1588
D0201	4822 130 31537	DIODE 1S1588
D0202	4822 130 31537	DIODE 1S1588
D0203	4822 130 31537	DIODE 1S1588
D0204	4822 130 31537	DIODE 1S1588
D0205	4822 130 31537	DIODE 1S1588
D0206	4822 130 31537	DIODE 1S1588
D0207	4822 130 31537	DIODE 1S1588
D0208	4822 130 31537	DIODE 1S1588
D0209	4822 130 31537	DIODE 1S1588
D0308	5322 130 81626	DIODE HZ2B-3
D0309	5322 130 81626	DIODE HZ2B-3
D0320	4822 130 31537	DIODE 1S1588
D0321	4822 130 31537	DIODE 1S1588
D0322	4822 130 31537	DIODE 1S1588
D0323	4822 130 31537	DIODE 1S1588
D0401	4822 130 31537	DIODE 1S1588
D0402	4822 130 31537	DIODE 1S1588
D0406	4822 130 31537	DIODE 1S1588
D0407	4822 130 31537	DIODE 1S1588
D0433	4822 130 32713	DIODE 1SS86
D0436	4822 130 31537	DIODE 1S1588
D0437	4822 130 33293	DIODE HZ5C-2
D0601	4822 130 32713	DIODE 1SS86
D0602	4822 130 31537	DIODE 1S1588
D0603	5322 130 81619	DIODE HZ3C-2
D0611	4822 130 31537	DIODE 1S1588
D0617	5322 130 81621	DIODE RD5.6EL3
D0618	4822 130 31537	DIODE 1S1588
D0619	4822 130 31537	DIODE 1S1588
D0627	4822 130 31537	DIODE 1S1588
D0628	4822 130 31537	DIODE 1S1588
D0629	4822 130 31537	DIODE 1S1588
D0630	4822 130 31537	DIODE 1S1588
D0631	4822 130 31537	DIODE 1S1588
D0632	4822 130 31537	DIODE 1S1588
D0633	4822 130 31537	DIODE 1S1588
D0634	4822 130 31537	DIODE 1S1588
D0635	4822 130 31537	DIODE 1S1588
D0640	4822 130 31537	DIODE 1S1588
D0726	4822 130 31537	DIODE 1S1588
D0819	4822 130 32713	DIODE 1SS86
D0820	4822 130 31537	DIODE 1S1588
D0821	4822 130 31537	DIODE 1S1588
D0822	5322 130 80457	DIODE 1SS83

POS NR	ORDERING CODE	DESCRIPTION
D1001	5322 130 81538	BRIDGE 1G4B-41
D1002	5322 130 81538	BRIDGE 1G4B-41
D1003	5322 130 81617	DIODE RD13EL
D1004	4822 130 31537	DIODE 1S1588
D1005	5322 130 81621	DIODE RD5.6EL3
D1011	5322 130 81617	DIODE RD13EL
D1019	4822 130 31537	DIODE 1S1588
D2001	4822 130 31537	DIODE 1S1588
D2006	5322 130 81621	DIODE RD5.6EL3
D2008	4822 130 31537	DIODE 1S1588
D2009	4822 130 31537	DIODE 1S1588
D2010	5322 130 81618	DIODE Y-16GA
D2011	5322 130 81618	DIODE Y-16GA
D2012	5322 130 81618	DIODE Y-16GA
D2013	5322 130 81618	DIODE Y-16GA
D2014	5322 130 81618	DIODE Y-16GA
D2015	5322 130 81618	DIODE Y-16GA
D2016	5322 130 81618	DIODE Y-16GA
D2017	5322 130 81618	DIODE Y-16GA
D3008	5322 130 81626	DIODE HZ2B-3
D3009	5322 130 81626	DIODE HZ2B-3
D3010	4822 130 31537	DIODE 1S1588
D3013	5322 130 80457	DIODE 1SS83
D3015	5322 130 80457	DIODE 1SS83
D3018	4822 130 30842	DIODE BAV21
D3019	4822 130 30842	DIODE BAV21
D3021	5322 130 80457	DIODE 1SS83
D3022	5322 130 80457	DIODE 1SS83
D3024	4822 130 30842	DIODE BAV21
D3025	5322 130 81616	DIODE ERB26-20
D3026	4822 130 31537	DIODE 1S1588
D3029	4822 130 31537	DIODE 1S1588
D3031	4822 130 31537	DIODE 1S1588
D3035	5322 130 81622	DIODE HZ36L-2
D3036	5322 130 81622	DIODE HZ36L-2
D3037	5322 130 81622	DIODE HZ36L-2

#### 9.4.7 Transistors

POS NR	ORDERING CODE	DESCRIPTION
Q0001	5322 130 61738	F.E.T 2SK107-3
Q0002	4822 130 42301	TRANSISTOR 2SC945-Q
Q0003	5322 130 44666	TRANSISTOR 2SA844-D
Q0004	4822 130 42301	TRANSISTOR 2SC945-Q
Q0005	4822 130 41822	TRANSISTOR 2SA1005-L
Q0006	4822 130 41822	TRANSISTOR 2SA1005-L
Q0007	4822 130 60093	TRANSISTOR 2SA838-B
Q0008	4822 130 60093	TRANSISTOR 2SA838-B
Q0009	4822 130 60093	TRANSISTOR 2SA838-B
Q0010	4822 130 60093	TRANSISTOR 2SA838-B
Q0011	5322 130 61734	TRANSISTOR 2SC1907
Q0101	5322 130 61738	F.E.T 2SK107-3
Q0102	4822 130 42301	TRANSISTOR 2SC945-Q
Q0103	5322 130 44666	TRANSISTOR 2SA844-D

POS NR	ORDERING CODE	DESCRIPTION
Q0104	4822 130 42301	TRANSISTOR 2SC945-Q
Q0105	4822 130 41822	TRANSISTOR 2SA1005-L
Q0106	4822 130 41822	TRANSISTOR 2SA1005-L
Q0107	4822 130 60093	TRANSISTOR 2SA838-B
Q0108	4822 130 60093	TRANSISTOR 2SA838-B
Q0109	4822 130 60093	TRANSISTOR 2SA838-B
Q0110	4822 130 60093	TRANSISTOR 2SA838-B
Q0111	4822 130 60093	TRANSISTOR 2SA838-B
Q0112	4822 130 60093	TRANSISTOR 2SA838-B
Q0201	5322 130 61727	TRANSISTOR 2SA781
Q0202	5322 130 61727	TRANSISTOR 2SA781
Q0203	5322 130 44666	TRANSISTOR 2SA844-D
Q0204	5322 130 44666	TRANSISTOR 2SA844-D
Q0301	5322 130 61734	TRANSISTOR 2SC1907
Q0302	5322 130 61734	TRANSISTOR 2SC1907
Q0303	5322 130 61731	TRANSISTOR 2SA1206-L
Q0304	5322 130 61731	TRANSISTOR 2SA1206-L
Q0305	5322 130 61732	TRANSISTOR 2SC1730-L
Q0306	5322 130 61732	TRANSISTOR 2SC1730-L
Q0307	5322 130 61737	TRANSISTOR 2SC3423-Y
Q0309	5322 130 61728	TRANSISTOR 2SA1360-Y
Q0310	5322 130 61728	TRANSISTOR 2SA1360-Y
Q0311	5322 130 61736	TRANSISTOR 2SC2570
Q0312	5322 130 61736	TRANSISTOR 2SC2570
Q0401	4822 130 60093	TRANSISTOR 2SA838-B
Q0402	4822 130 60093	TRANSISTOR 2SA838-B
Q0403	5322 130 61738	F.E.T 2SK107-3
Q0404	5322 130 61734	TRANSISTOR 2SC1907
Q0405	5322 130 61734	TRANSISTOR 2SC1907
Q0406	5322 130 44666	TRANSISTOR 2SA844-D
Q0407	5322 130 44666	TRANSISTOR 2SA844-D
Q0408	5322 130 44666	TRANSISTOR 2SA844-D
Q0409	5322 130 44666	TRANSISTOR 2SA844-D
Q0410	4822 130 60926	F.E.T 2SK117-BL
Q0411	4822 130 60093	TRANSISTOR 2SA838-B
Q0412	4822 130 41726	TRANSISTOR 2SA1015-Y
Q0413	5322 130 61734	TRANSISTOR 2SC1907
Q0414	5322 130 61738	F.E.T 2SK107-3
Q0601	5322 130 61734	TRANSISTOR 2SC1907
Q0602	5322 130 44666	TRANSISTOR 2SA844-D
Q0603	5322 130 44666	TRANSISTOR 2SA844-D
Q0604	5322 130 44666	TRANSISTOR 2SA844-D
Q0605	5322 130 44666	TRANSISTOR 2SA844-D
Q0606	4822 130 60926	F.E.T 2SK117-BL
Q0607	4822 130 60926	F.E.T 2SK117-BL
Q0608	5322 130 44666	TRANSISTOR 2SA844-D
Q0609	4822 130 42301	TRANSISTOR 2SC945-Q
Q0610	5322 130 44666	TRANSISTOR 2SA844-D
Q0611	5322 130 61733	TRANSISTOR 2SC1843-E
Q0612	5322 130 44666	TRANSISTOR 2SA844-D
Q0613	4822 130 42301	TRANSISTOR 2SC945-Q
Q0614	4822 130 42301	TRANSISTOR 2SC945-Q
Q0615	5322 130 61734	TRANSISTOR 2SC1907
Q0616	4822 130 42301	TRANSISTOR 2SC945-Q
Q0617	4822 130 42301	TRANSISTOR 2SC945-Q
Q0801	4822 130 42301	TRANSISTOR 2SC945-Q
Q0802	4822 130 42301	TRANSISTOR 2SC945-Q

POS NR	ORDERING CODE	DESCRIPTION
Q0803	4822 130 60926	TRANSISTOR 2SA1015-Y
Q0804	4822 130 60926	TRANSISTOR 2SA1015-Y
Q0805	5322 130 61734	TRANSISTOR 2SC1907
Q0806	5322 130 61734	TRANSISTOR 2SC1907
Q0807	5322 130 61734	TRANSISTOR 2SC1907
Q0808	4822 130 60093	TRANSISTOR 2SA838-B
Q0809	5322 130 61729	TRANSISTOR 2SD668-A
Q0810	5322 130 61729	TRANSISTOR 2SD668-A
Q0811	5322 130 61726	TRANSISTOR 2SB648-A
Q0812	5322 130 61726	TRANSISTOR 2SB648-A
Q1001	4822 130 42326	TRANSISTOR 2SB834-Y
Q1002	4822 130 42305	TRANSISTOR 2SD880-Y
Q1003	5322 130 43516	TRANSISTOR 2SB861-C
Q1004	4822 130 42305	TRANSISTOR 2SD880-Y
Q2001	4822 130 42305	TRANSISTOR 2SD880-Y
Q3001	5322 130 61734	TRANSISTOR 2SC1907
Q3002	5322 130 61734	TRANSISTOR 2SC1907
Q3003	5322 130 61735	TRANSISTOR 2SC2371-L
Q3004	5322 130 61735	TRANSISTOR 2SC2371-L
Q3005	5322 130 61735	TRANSISTOR 2SC2371-L
Q3006	5322 130 61735	TRANSISTOR 2SC2371-L
Q3007	4822 130 60926	F.E.T 2SK117-BL
Q3008	5322 130 44666	TRANSISTOR 2SA844-D
Q3009	5322 130 44666	TRANSISTOR 2SA844-D
Q3010	4822 130 41927	TRANSISTOR 2SC1846-R
Q3011	4822 130 41927	TRANSISTOR 2SC1846-R

#### 9.4.8 Integrated circuits

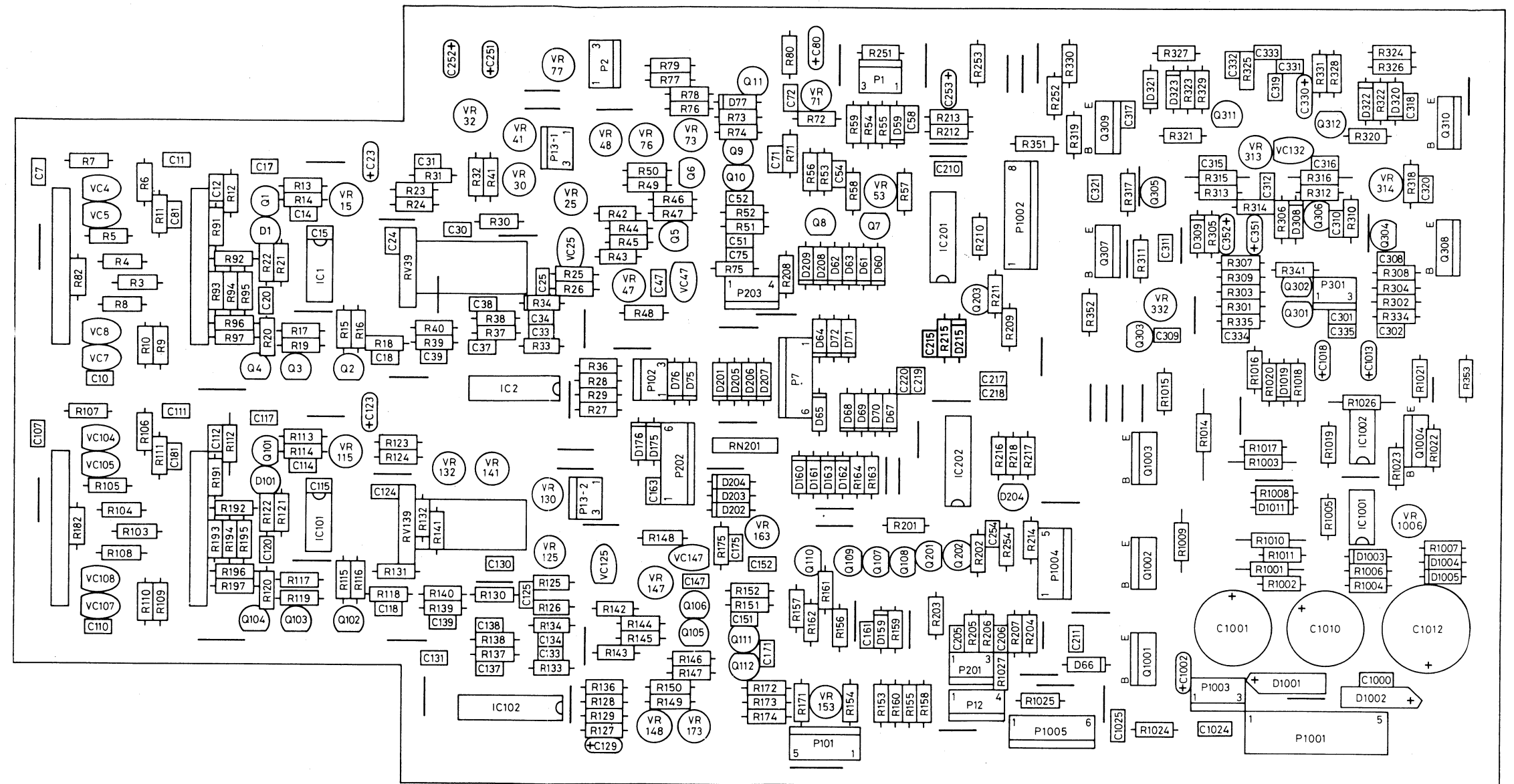
POS NR	ORDERING CODE	DESCRIPTION
IC0001	5322 209 61209	LF13741N
IC0002	5322 209 11225	CA3086
IC0101	5322 209 61209	LF13741N
IC0102	5322 209 11225	CA3086
IC0201	5322 209 73611	SN74LS00N
IC0202	5322 209 81647	SN74LS74N
IC0401	5322 209 73611	SN74LS00N
IC0601	5322 209 84971	SN74LS112N
IC0602	4822 209 71629	TC4053BP
IC0603	5322 130 42216	TL081CP
IC1001	4822 209 72939	UPC4558C
IC1002	4822 209 72939	UPC4558C
IC2001	5322 209 61209	LF13741N
IC4001	5322 209 61208	TC4011BP



**9.4.9 Miscellaneous**

<u>POS NR</u>	<u>ORDERING CODE</u>	<u>DESCRIPTION</u>
L00332	5322 157 60296	INDUCTOR 2,2 $\mu$ H
L00333	5322 157 60296	INDUCTOR 2,2 $\mu$ H
L02001	5322 157 60298	TRACE ROTATION COIL
L02008	5322 157 60297	INDUCTOR 100 $\mu$ H
LD0640	5322 130 81625	LED SLR-34DU (ORANGE)
NE3001	5322 134 40959	NEON LAMP
NE3002	5322 134 40959	NEON LAMP
PL3001	5322 134 40961	SCALE ILLUM LAMP 14 V - 80 mA
PL3002	5322 134 40961	SCALE ILLUM LAMP 14 V - 80 mA
T01001	5322 146 30811	POWER TRANSFORMER
T02001	5322 146 30812	CONVERTER TRANSFORMER
V02001	5322 131 20282	CRT 150DEB31

## 10 CIRCUIT DIAGRAMS + PCB LAY OUTS



MAT3428  
890428

Figure 10.1 Vertical pcb lay out

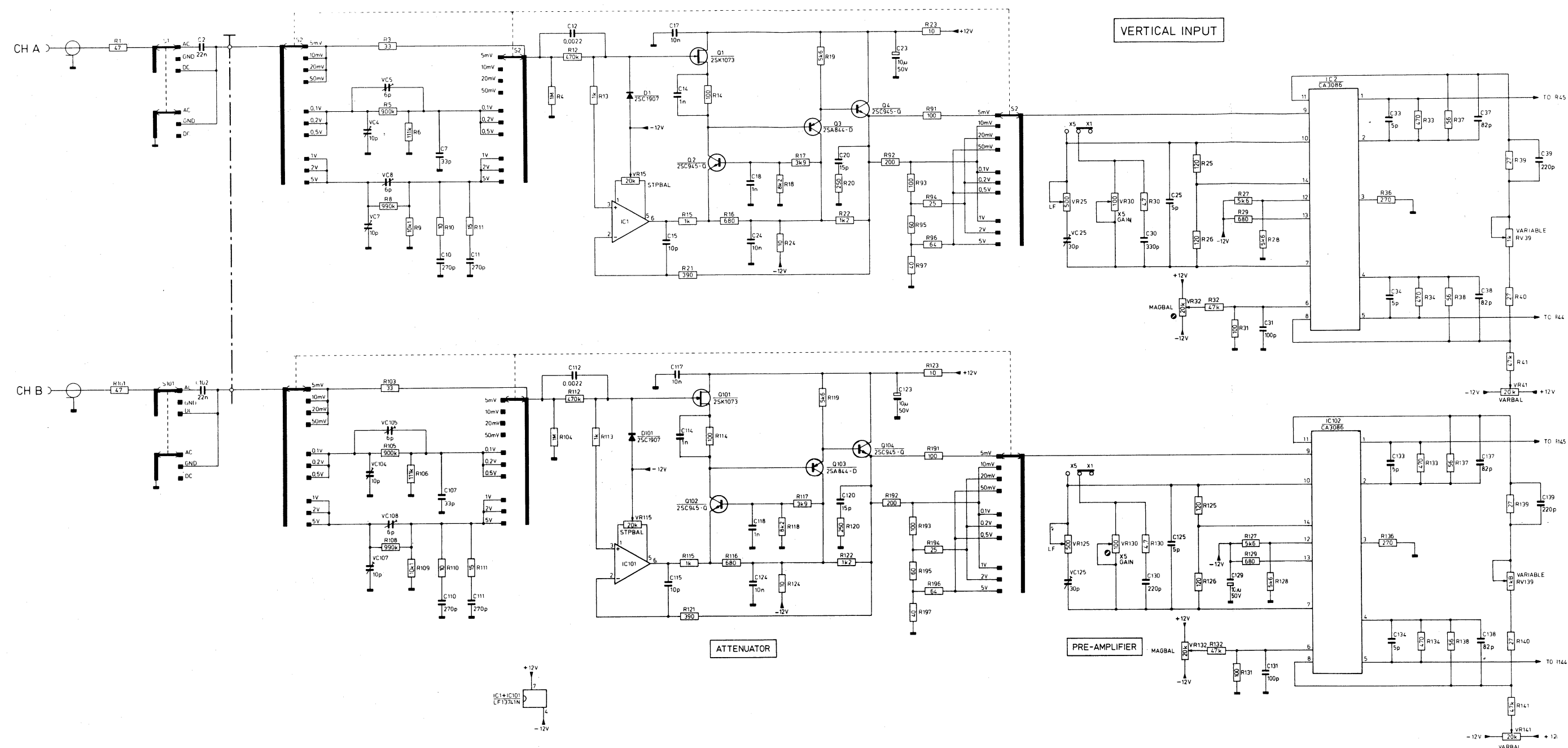
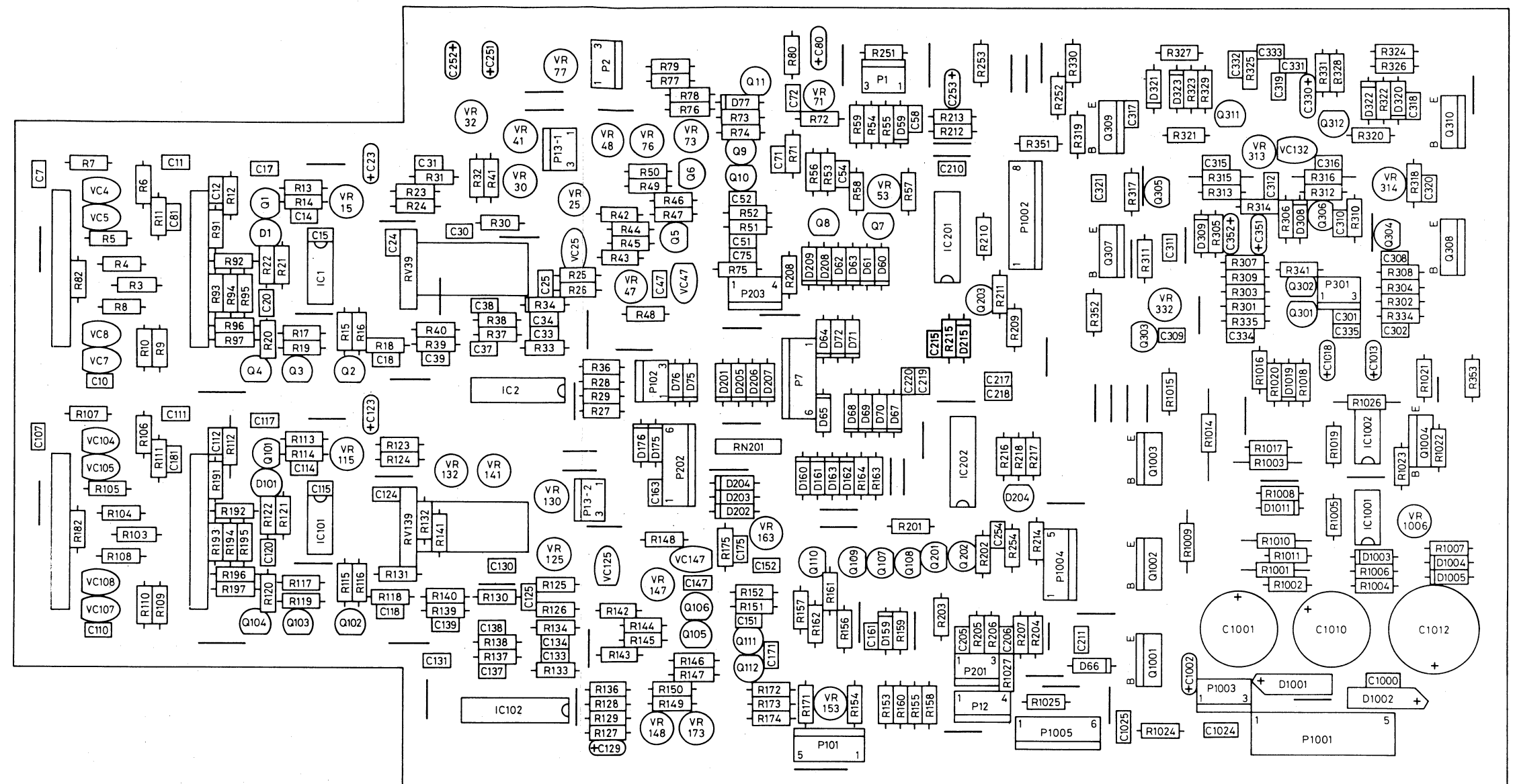


Figure 10.2 Circuit diagram of vertical input



MAT3428  
890428

Figure 10.3 Vertical pcb lay out

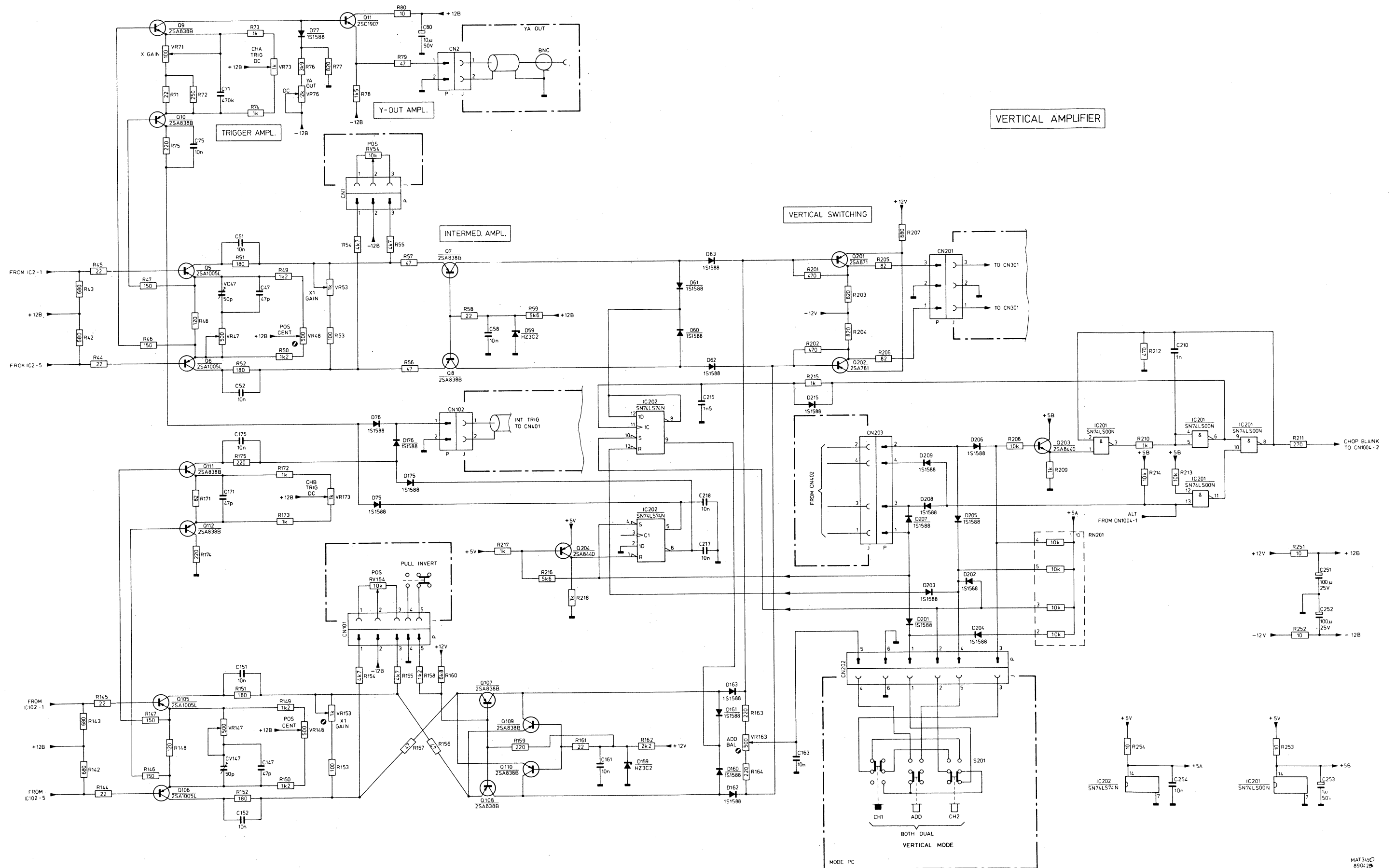
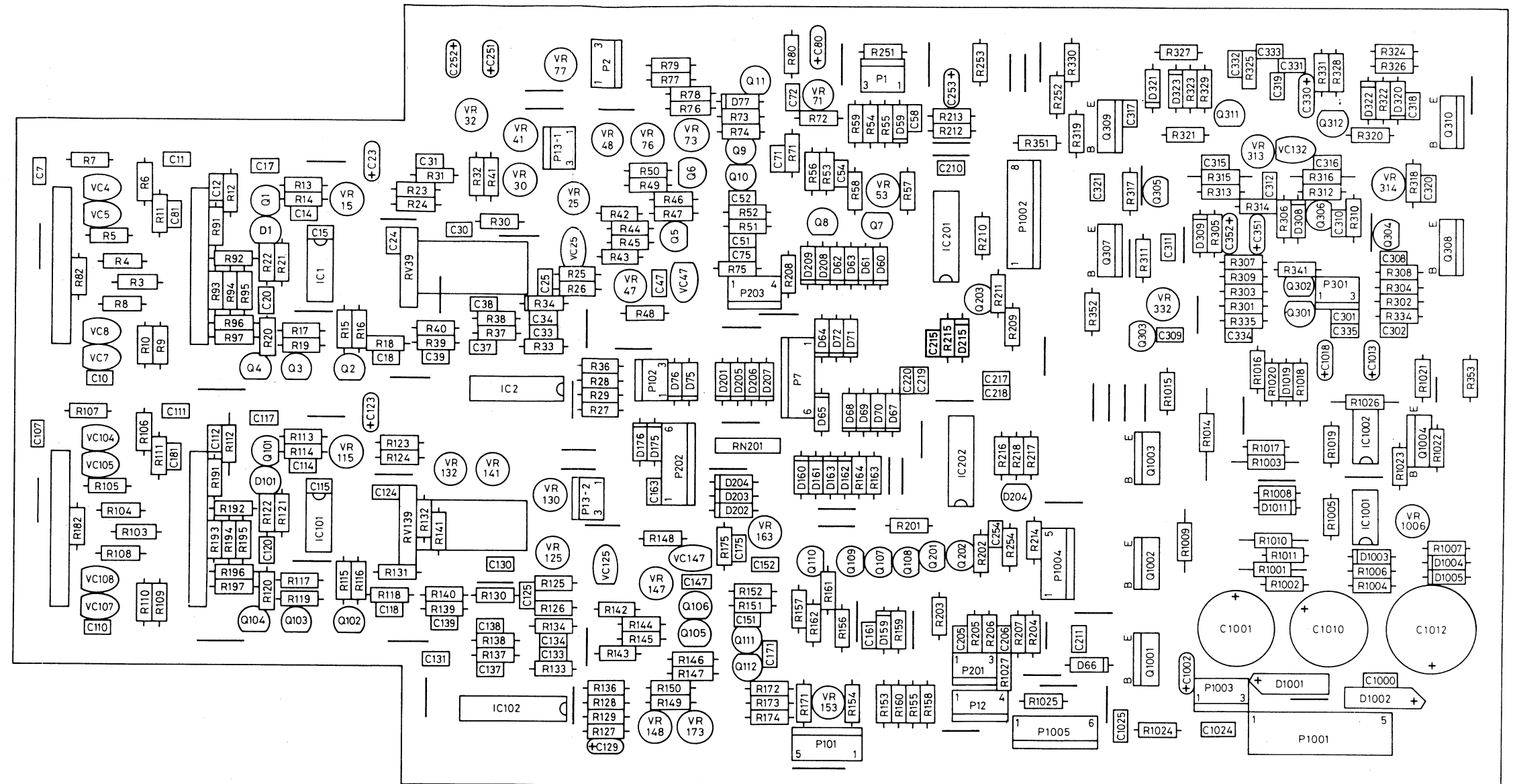


Figure 10.4 Circuit diagram of vertical amplifier



**Figure 10.5 Vertical pcb lay out**

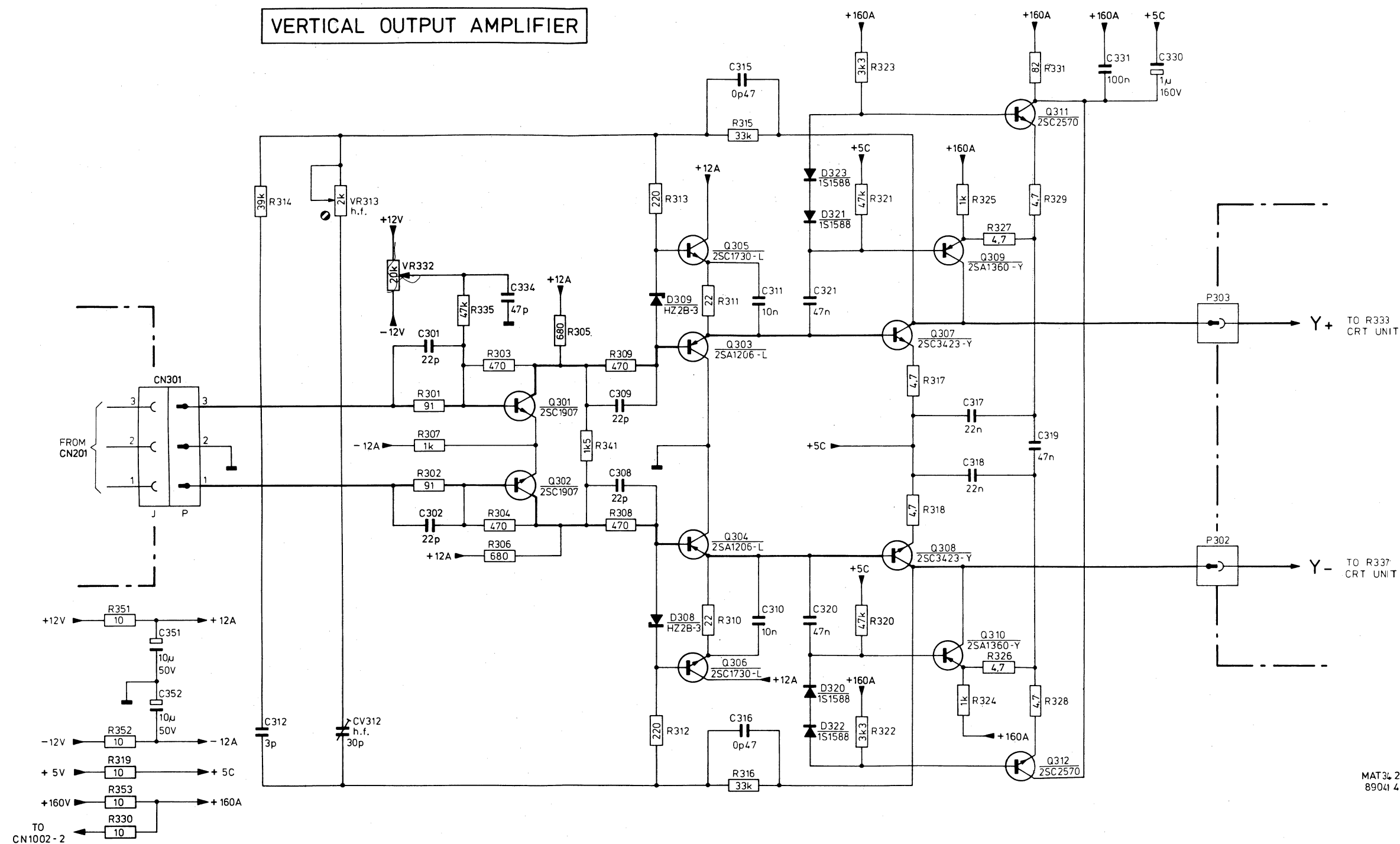
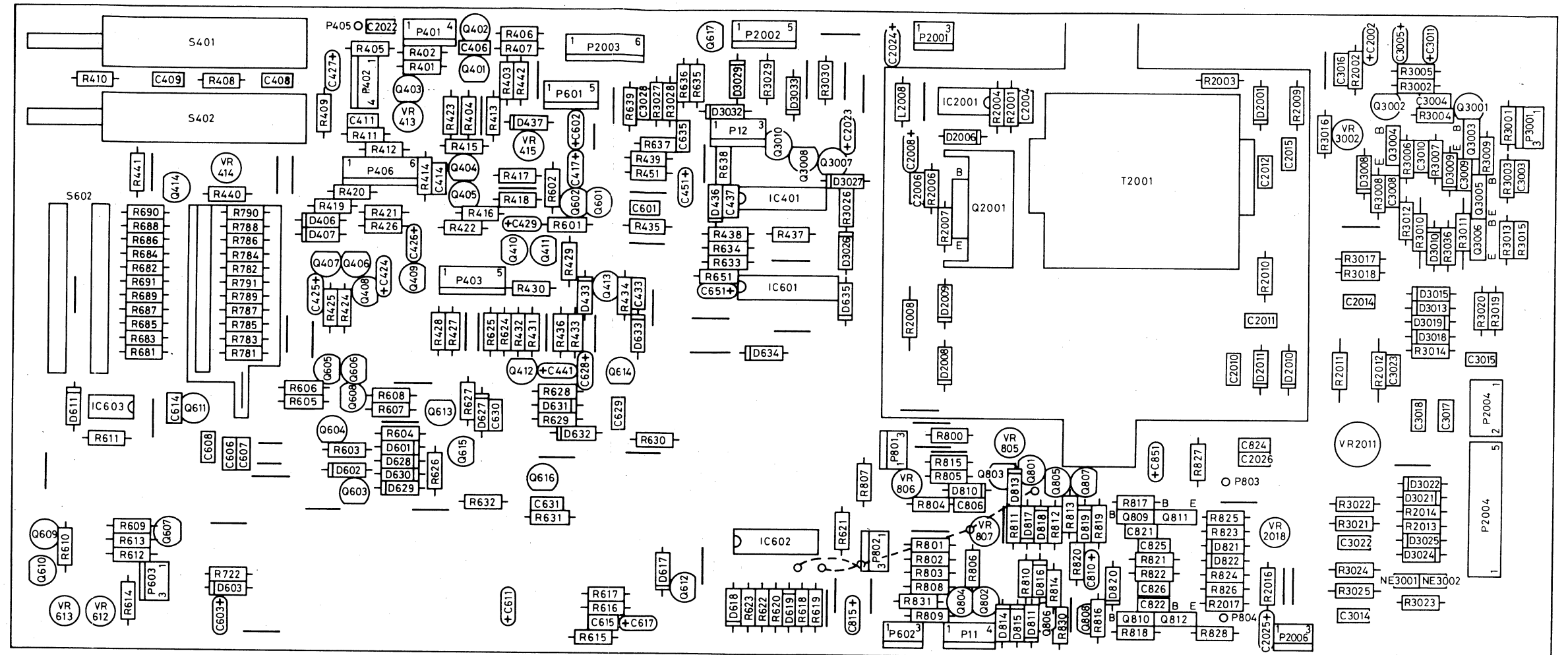


Figure 10.6 Circuit diagram of vertical output amplifier





**Figure 10.7 Horizontal pcb lay out**

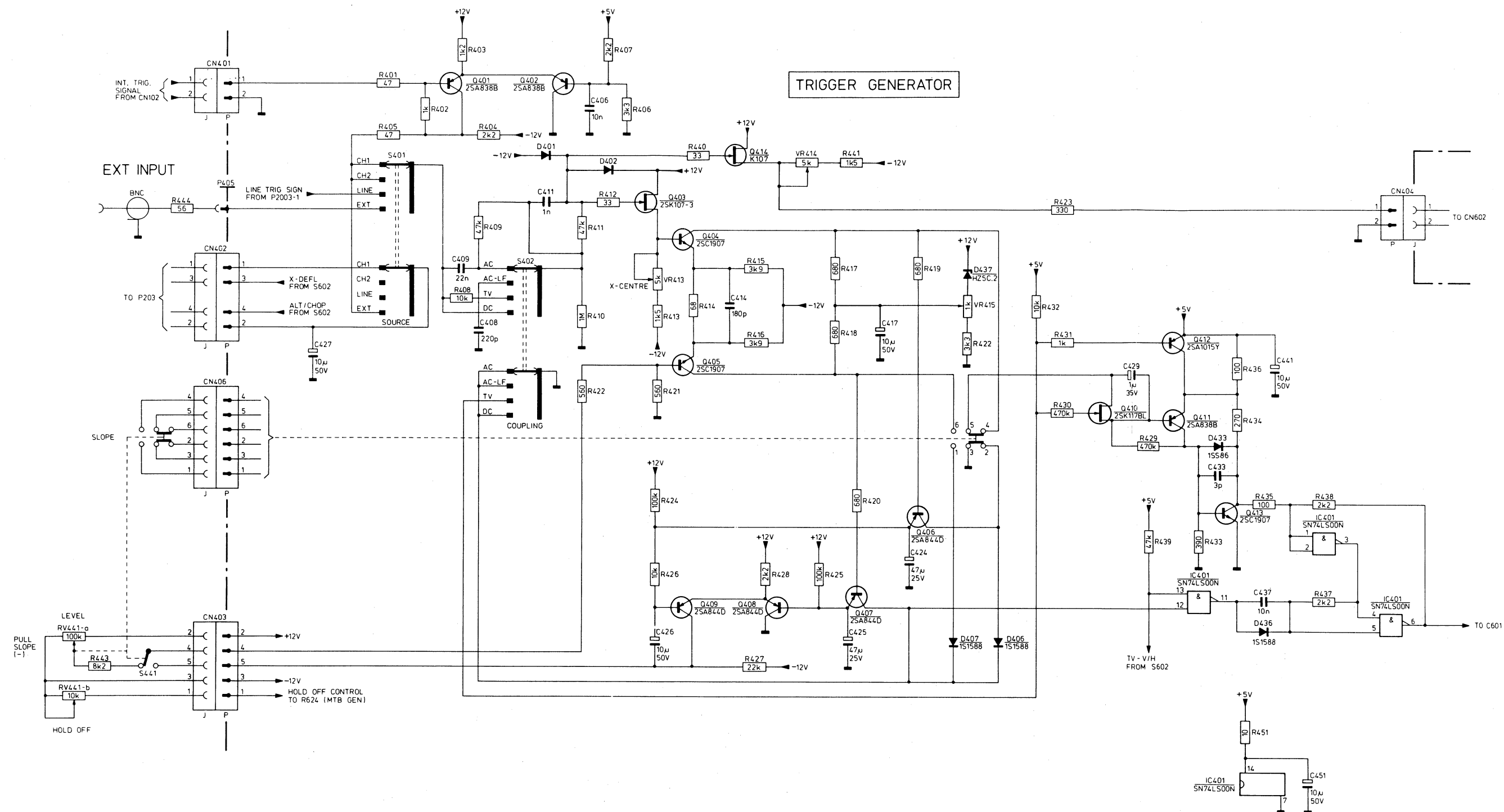
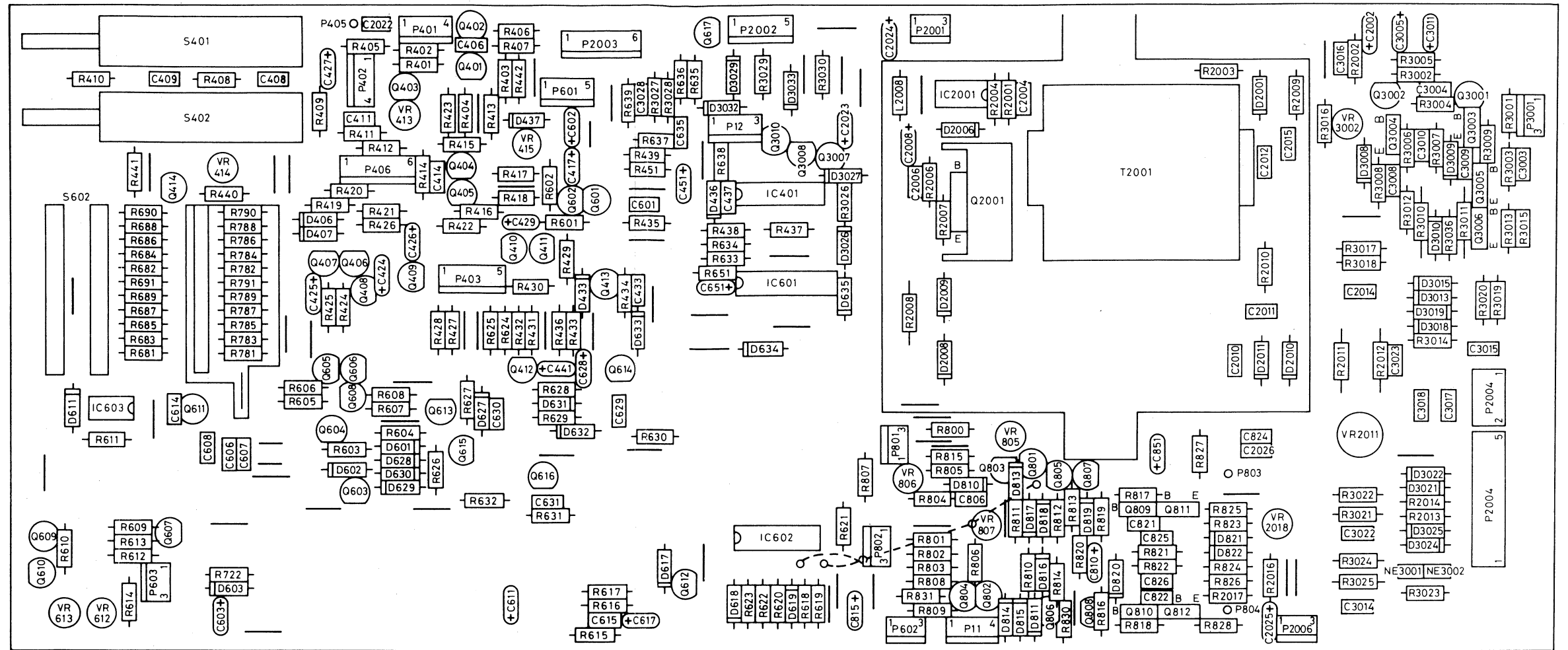


Figure 10.8 Circuit diagram of trigger generator



**Figure 10.9 Horizontal pcb lay out**

## HORIZONTAL OUTPUT AMPLIFIER

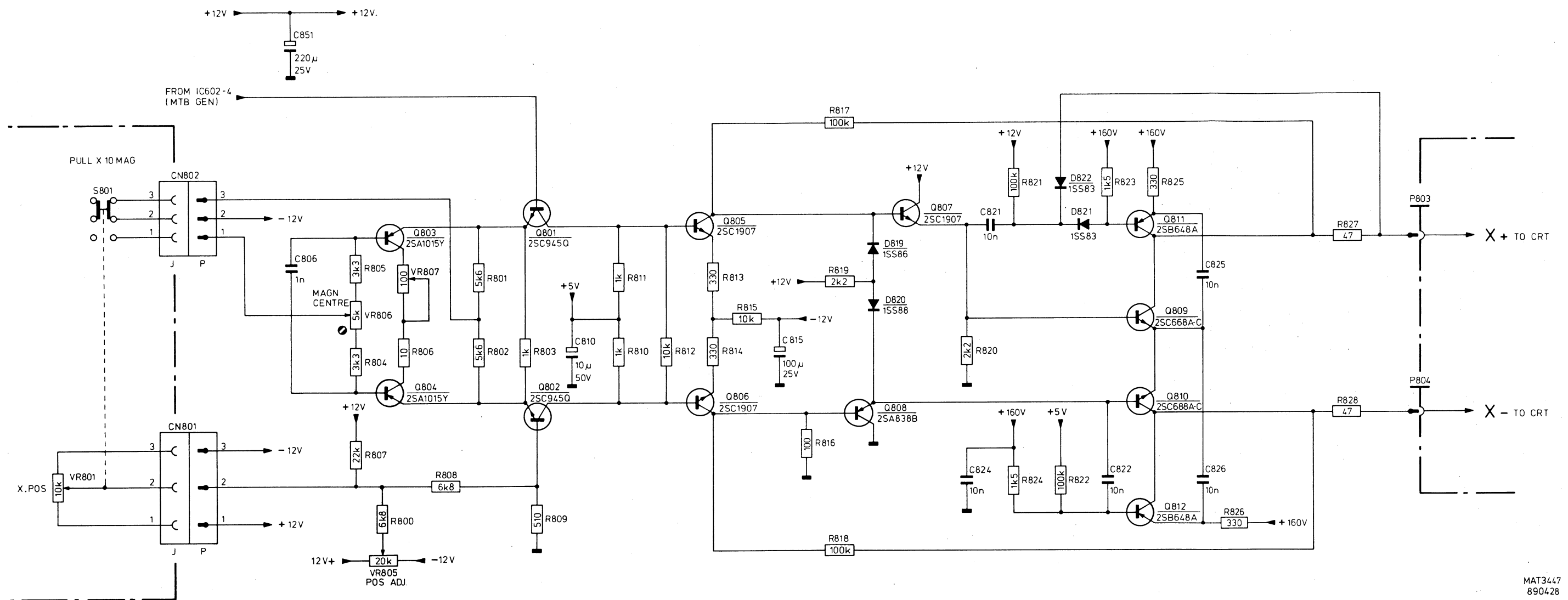


Figure 10.12 Circuit diagram of horizontal output amplifier

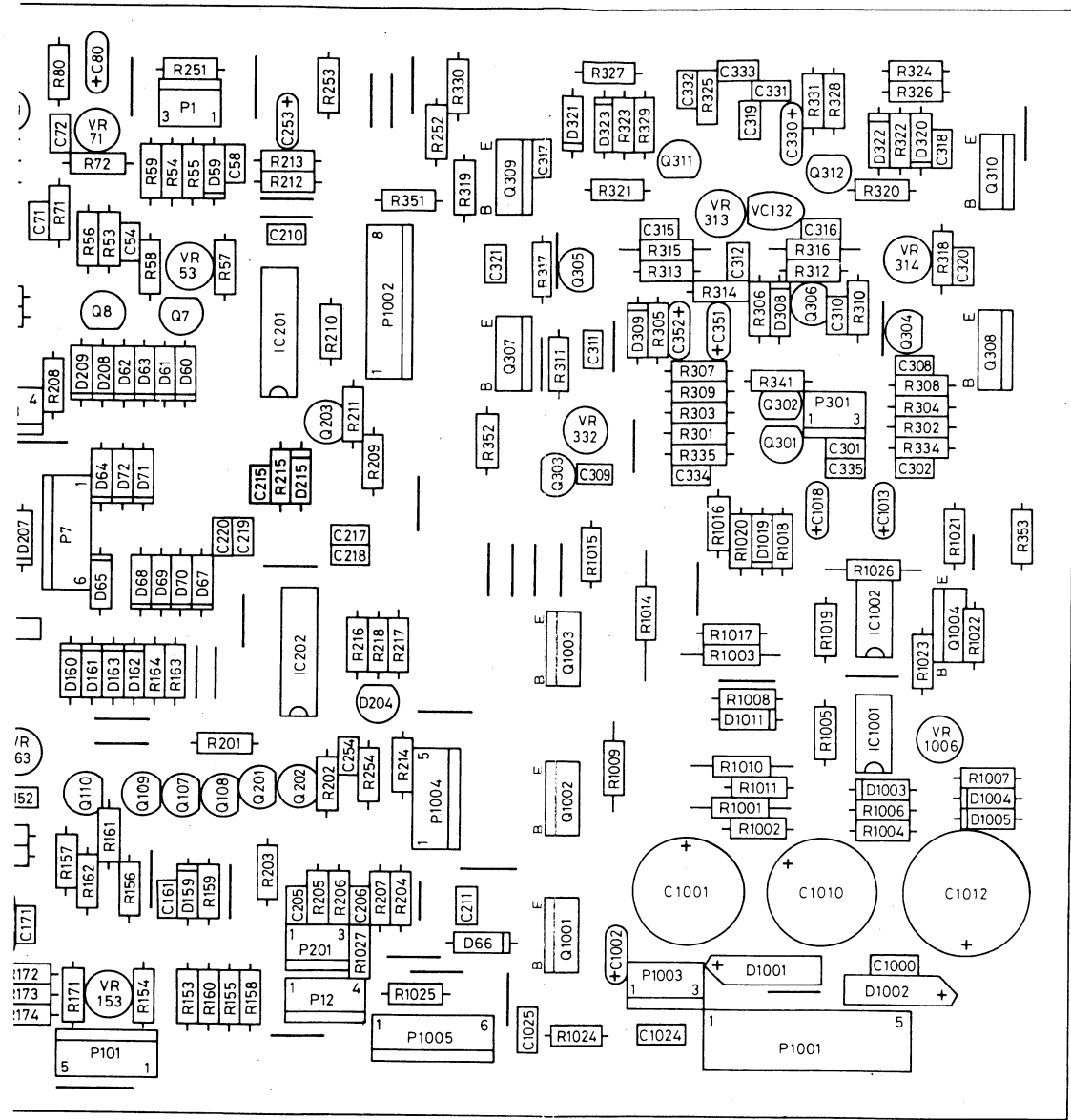


Figure 10.13 Vertical pcb lay out showing parts of power supply

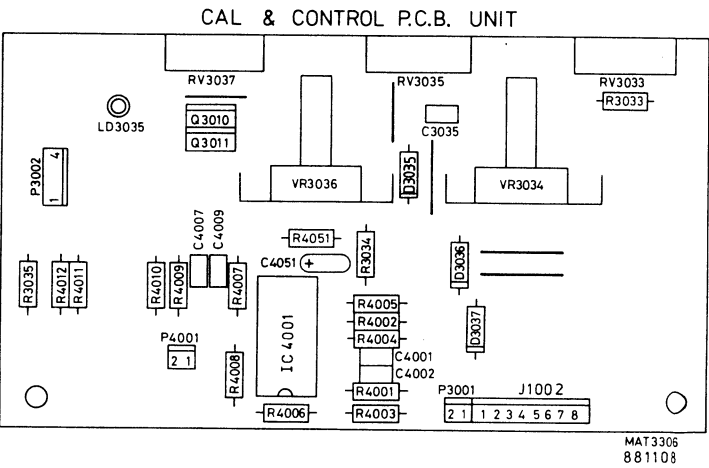


Figure 10.14 Cal and control pcb lay out

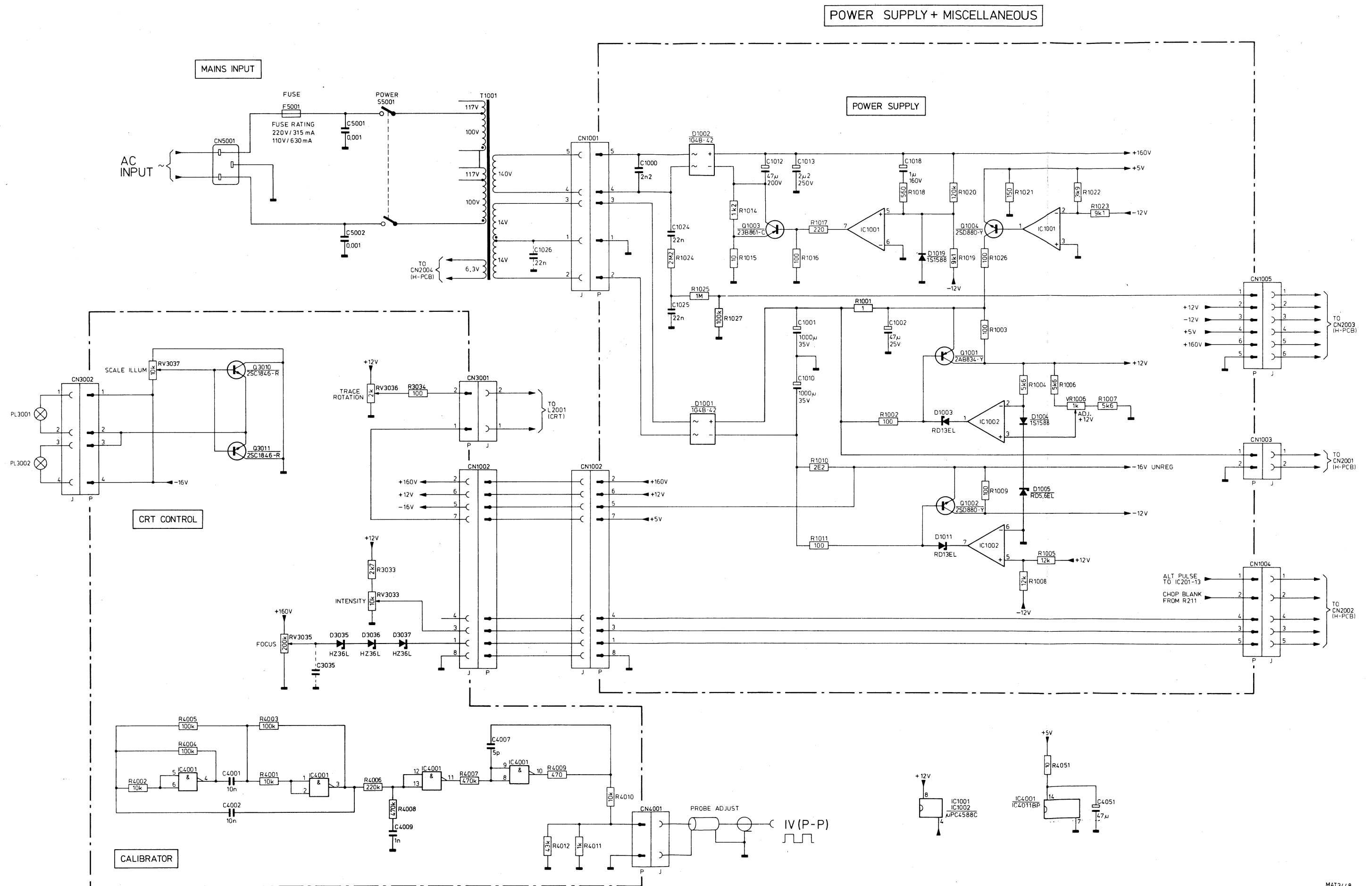


Figure 10.15 Circuit diagram of power supply + miscellaneous



**Figure 10.16 Horizontal pcb lay out**



*Figure 10.17 CRT pcb lay out*

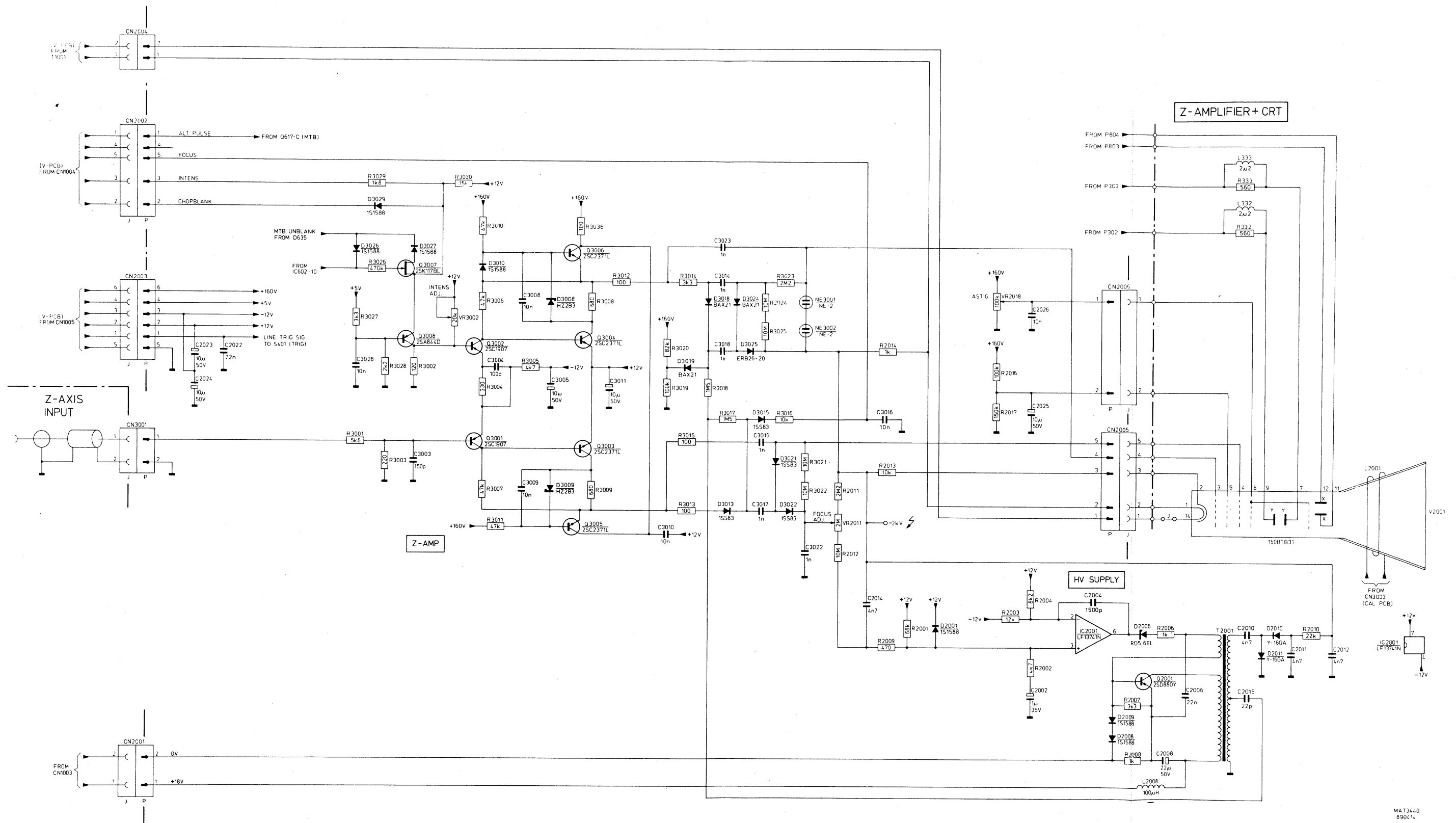


Figure 10.18 Circuit diagram of Z - amplifier + CRT



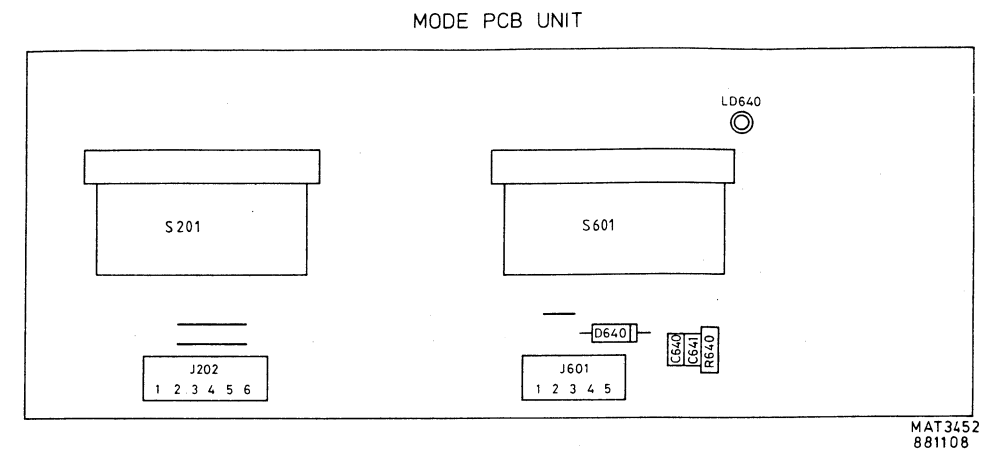


Figure 10.19 Mode pcb lay out

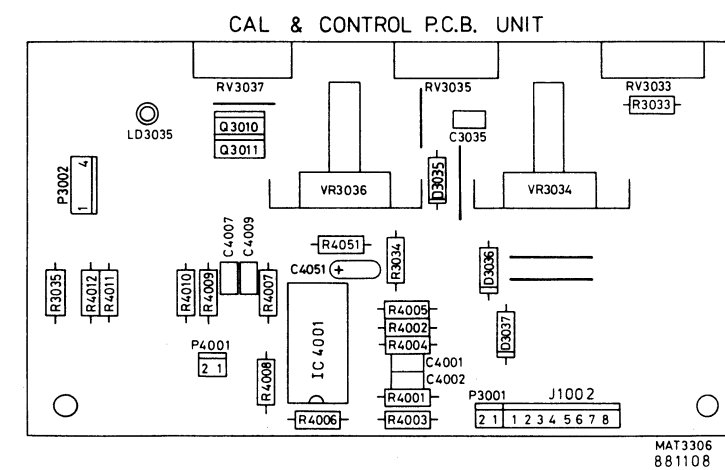


Figure 10.20 Cal and control pcb lay out